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Option Values, Preservation Values and Recreational Benefits of Improved Water Quality: A Case Study of the South Platte River Basin, Colorado

Colorado State Univ, Fort Collins. Dept. of Economics

Prepared for

Health Effects Research Lab, Research Triangle Park, N.C.

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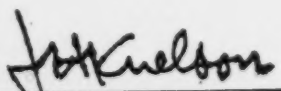
FOREWORD

The many benefits of our modern, developing, industrial society are accompanied by certain hazards. Careful assessment of the relative risk of existing and new man-made environmental hazards is necessary for the establishment of sound regulatory policy. These regulations serve to enhance the quality of our environment in order to promote the public health and welfare and the productive capacity of our Nation's population.

The Health Effects Research Laboratory, Research Triangle Park, conducts a coordinated environmental health research program in toxicology, epidemiology, and clinical studies using human volunteer subjects. These studies address problems in air pollution, non-ionizing radiation, environmental carcinogenesis and the toxicology of pesticides as well as other chemical pollutants. The Laboratory develops and revises air quality criteria documents on pollutants for which national ambient air quality standards exist or are proposed, provides the data for registration of new pesticides or proposed suspension of those already in use, conducts research on hazardous and toxic materials, and is preparing the health basis for non-ionizing radiation standards. Direct support to the regulatory function of the Agency is provided in the form of expert testimony and preparation of affidavits as well as expert advice to the Administrator to assure the adequacy of health care and surveillance of persons having suffered imminent and substantial endangerment of their health.

Pollution may impact upon man either directly by altering his health status or indirectly by altering the environment and his ability to derive enjoyment thereof. This study attempts to measure, in economic terms, some of the disamenities which are imposed upon man from the pollution of our streams and rivers. These disamenities are measured by estimating the willingness of individuals and households to pay for the preservation and improvement of the quality of water in selected river basins. The total annual benefits from improved water quality in the South Platte Basin of Colorado was estimated to be in excess of $60 million per year, of which nearly one half was directly related to water based recreation uses and the remaining to non user activities, i.e., the desire to maintain and preserve the quality of the water for future use or generations.



John H. Knelson, M.D.
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ABSTRACT

This is believed to be the first empirical test of the concept of option value for any non-market good. Application of the bidding game technique was successful in meeting the primary study objective of measuring the option value of improved water quality. Also included are improved estimates of the benefits to recreational users of enhanced water quality, the existence value of a natural ecosystem, and the value of its bequest to future generations. The relationship between the value of improved water quality and several socioeconomic variables was tested with regression and other statistical procedures. The report is based on direct interviews with 202 residents of Denver and Fort Collins located in the South Platte River Basin, Colorado. Interviewees responded to the survey within the context of improving the quality of water degraded by heavy metals from post mining activities and preventing future degradation from such sources. Substantial benefits from improved water quality are indicated. Recreation user households interviewed reported they were willing to pay an average of $56.68 annually for improved water quality by 1983 to enhance enjoyment of water-based recreation activities in the River Basin. Willingness to pay for the option to choose to engage in water-based recreation activities in the future contributed $22.60 annually to resident user household values. Adding the two values, the total recreation value of improved water quality to the 80.8 percent of the households who expect to continue to use waterways in the River Basin for recreation activities averaged $79.28 annually. This was equivalent to $5.26 per household activity day in 1976. Preservation value of water quality was equal to nearly one-half of recreation values. The 19.2 percent of the resident households interviewed who do not expect to use the River Basin for recreation activities in the future reported they were willing to pay an average of $24.98 annually for the existence of a natural ecosystem and $16.97 annually to bequest clean water to future generations, for a total preservation value of $41.95 annually. As a first approximation, the existence and bequest value estimates for non-user households were extrapolated to all residents of the River Basin, including users. Future research should measure existence and bequest values of recreation users as well as non-users to test the reasonableness of this procedure.

TABLE OF CONTENTS

	Page
FOREWORD	iii
ABSTRACT	iv
TABLE OF CONTENTS	v
LIST OF FIGURES	vii
LIST OF TABLES	viii
ACKNOWLEDGEMENTS	xi
CONCLUSIONS	xii
SECTIONS	
1. INTRODUCTION	1
Background and Scope of Study	1
Objective and Plan of Study	2
2. CONCEPTUAL FRAMEWORK	5
Review of the Theoretical Literature on Option Value	5
An Empirically Testable Formulation of Preservation Values	9
Option Value and Irreplaceable Environments	9
Existence Value	13
Bequest Value	14
3. RESEARCH PROCEDURES	16
Study Area	16
Sample Selection	19
Contacting Respondents	23
Color Photographs	25
Method of Payment	28
Bidding Game	29
4. USE AND NON-USE VALUES	34
Option and Recreation Use Value	34
Existence and Bequest Value	37
Annual Benefits and Present Value of Future Benefits	39
Method of Payment	41
River Basin Versus State Values of Improved Water Quality	43
Delay to Year 2000	45
Level of Water Quality	47
Inter-City Comparisons	49
5. SOCIOECONOMIC VARIABLES	51
Household Income	51
Sex of Respondent	55
Employment	57
Education	60
Former Residence	60
Reasons for Moving	63
Permanence of Residence	63
Age of Respondent	66
Size of Household	66
Recreation Use	69

Page

6. APPENDIX 73
References 73
Water Quality Opinion Survey 79
Environmental Awareness 83
Statistical Analysis 85

LIST OF FIGURES

Number		Page
1	The South Platte River Basin	17
2	Three Levels of Water Quality, South Platte River Basin, Colorado, 1976	26

LIST OF TABLES

Number		Page
1	Sample Response in Denver and Fort Collins, Colorado, 1976	20
2	Comparison of Population and Sample Demographic Profile Estimates of Denver and Fort Collins, Colorado, 1976	22
3	Heavy Metal Pollution at the Three Photograph Sites, South Platte River Basin, Colorado, 1973	27
4	Total Number of Respondents Interviewed Compared to the Number Answering Questions Relating to Value of Water Quality and the Number Willing to Pay, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976	31
5	Willingness of Recreation User Households to Pay Additional Sales Tax to Improve Water Quality, Denver, Fort Collins and South Platte River Basin, Colorado, 1976	35
6	Willingness of Recreation User and Non-User Households to Pay Additional Sales Tax to Improve Water Quality for Preservation of the Existence of a Natural Ecosystem and its Bequest to Future Generations, Denver, Fort Collins and South Platte River Basin, Colorado, 1976	38
7	Annual Value and Present Value of Benefits from Water Quality Improvement for Recreation, Option, Existence, and Bequest Demands by Residents of the South Platte River Basin, 1976	40
8	Willingness of Resident Households to Pay Additional Water Bill to Improve Water Quality, Denver, Fort Collins and South Platte River Basin, Colorado, 1976	42
9	Willingness of South Platte River Basin Residents to Pay an Additional Sales Tax to Improved Waterways Throughout Colorado, 1976	44
10	Effects of Delay to the Year 2000 on Willingness to Pay an Additional Sales Tax to Improve Water Quality in South Platte River Basin, Colorado, 1976	46
11	Effect of Level of Water Pollution Control on Willingness of Residents to Pay an Additional Sales Tax to Improve Water Quality for Recreation Use in the South Platte River Basin, Colorado, 1976	48

Number		Page
12	Regression Coefficients of Significant Socioeconomic Variables, Denver and Fort Collins, Colorado, 1976 . . .	52
13	Household Income and Willingness to Pay Additional Sales Tax for Improved (C-A) Water Quality, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976	53
14	Marginal Effect of a Change of Income on Willingness to Pay Additional Sales Tax for Improved Water Quality, at Various Age Levels, Denver Metropolitan Area, Colorado, 1976	54
15	Sex of Respondents and Willingness to Pay Additional Sales Tax for Improved (C-A) Water Quality, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976	56
16	Where People Work and Willingness to Pay Additional Sales Tax for Improved (C-A) Water Quality, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976	58
17	Occupation and Willingness to Pay Additional Sales Tax for Improved (C-A) Water Quality, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976	59
18	Education and Willingness to Pay Additional Sales Tax for Improved (C-A) Water Quality, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976	61
19	Size of Place of Previous Residence and Willingness to Pay for Improved (C-A) Water Quality, Denver, Fort Collins and South Platte River Basin, Colorado, 1976	62
20	Reason for Moving to Colorado and Willingness to Pay Additional Sales Tax for Improved (C-A) Water Quality, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976	64
21	Permanence of Residence and Willingness to Pay Additional Sales Tax for Improved (C-A) Water Quality, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976	65
22	Age and Willingness to Pay Additional Sales Tax for Improved (C-A) Water Quality, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976	67

Number		Page
23	Size of Household and Willingness to Pay Additional Sales Tax for Improved (C-A) Water Quality, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976	68
24	Survey Respondents' Reported Annual Water-Based Recreation Activity Day in the South Platte River Basin and Willingness to Pay Additional Sales Tax for Improved (C-A) Water Quality, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976	70
25	Survey Respondents' Reported Annual Water-Based Recreation Activity Days in the United States and Willingness to Pay Additional Sales Tax for Improved (C-A) Water Quality, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976 . .	71
26	Environmental Awareness of Residents, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976 . .	84
27	Grouped T-test of Significant Difference Between Average Benefits from Improved Water Quality in Denver and Fort Collins, Colorado, 1976	91

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CONCLUSIONS

The purpose of this study was to develop and apply a procedure for measuring the benefits of improved water quality in terms of: (1) enhanced enjoyment of water-based recreation activities, (2) option values to choose to engage in water-based recreation activities in the future by avoiding irreversible mineral and energy pollution, (3) preservation value of the existence of a natural ecosystem and its bequest to future generations. Problems in the estimation of preservation values were discussed. This report is based on interviews of 202 resident households in Denver and Fort Collins, located in the South Platte River Basin, Colorado, in which the bidding game technique was used as an estimating technique. A number of statistical procedures, including regression analysis of the relationship between responses regarding user values and option values, were analyzed.

Benefits accrue to users of lakes and streams for fishing, boating and swimming as well as non-contact recreation activities such as picnicking and sightseeing near water from enhanced aesthetic satisfaction of such recreation experiences. Recreation user households interviewed reported they were willing to pay an average of $56.68 annually for improved water quality by 1983 to enhance enjoyment of water-based recreation activities in the River Basin.

Willingness to pay for the option to choose to engage in water-based recreation activities in the future contributed $22.60 annually to resident user household values, or about 40 percent. The Henry Model tested in this study was presented in terms of willingness to pay for the option of choosing between two environmental alternatives, either clean water or polluted water from energy and mineral development, at some future date under conditions of sufficient knowledge as to the relative benefits of each to the respondents. Adding the two values, the total recreation value of improved water quality to the 80.8 percent of the households who expect to continue to use waterways in the River Basin for recreation activities averaged $79.28 annually. This was equivalent to $5.26 per household activity day in 1976.

The preservation value of water quality improvement was equal to nearly one-half recreation use values. The 19.2 percent of the resident households interviewed who do not expect to use the River Basin for recreation activities in the future reported they were willing to pay an average of $24.98 annually for the existence of the natural ecosystem and $16.97 annually to bequest clean water to future generations, for a total preservation value of $41.95 annually.

As a first approximation, the existence and bequest value estimates for non-user households were extrapolated to all residents of the River Basin, including users. Recreation users reported preservation values of $66.87 annually under the assumption they would not engage in recreation

activities in the River Basin. This expected preservation value if no recreation activities were present could not be added to recreation use values.

Total annual benefits from water quality improvement in the South Platte River Basin were estimated at $61.1 million, including recreation use value of $26.4 million, option value of $10.5 million, existence value estimated at $14.4 million, and bequest value of $9.8 million. This was the estimated value for the 576,435 households in the River Basin in 1976.

The present value of a perpetual stream of annual benefits from water quality improvement in the South Platte River Basin was calculated as $958.5 million, including recreation use value of $414.1 million, option value of $165.1 million, existence value estimated at $225.9 million, and bequest value of $153.4 million. Present value is the amount of money that would have to be invested at 6 3/8 percent interest today in order to yield the specified annual benefits from improved water quality for an indefinite period of time. This is likely to prove a conservative estimate because of population growth and the exclusion of tourists who account for approximately 30-40 percent of total water-based recreation activities in the River Basin.

Residents reported they were willing to pay more for improved water quality when the method of hypothetical payment was an increase in sales tax compared to an increase in water bill. Willingness to pay for improved water quality was reported as about one-third as much in annual water bill as annual sales tax. Respondents were more reluctant to participate in the water bill value estimation procedure. This may have resulted from perceived inequities. Everyone including tourists pay sales tax whereas only property owners and indirectly renters, pay water bills. Moreover, willingness to pay additional sales tax was approximately the same percentage of the annual sales tax bill as the willingness to pay additional water bill was of the annual water bill. Thus, the selection among alternative methods of hypothetical payment affects the resulting values.

Results of this study suggest that the River Basin is an appropriate geographic area when evaluating willingness to pay for improved water quality. Respondents were also queried as to their willingness to pay if the added revenues were used throughout the state rather than only in the South Platte Basin. There was no significant difference between willingness to pay to improve water quality in the River Basin and throughout Colorado. It seems that residents of the River Basin are not willing to pay directly for improved water quality in other river basins in the state. Nearly 40 percent of the residents of the River Basin were of the opinion that the community as a whole should bear the primary responsibility for paying the costs of water quality improvement. An additional 15 percent reported the opinion that the polluting industries should pay the costs, while 30 percent favored sharing the costs between polluting industries and the people benefiting. Residents of other river basins in the state may be willing to pay to improve water quality in their local areas. River basin values appear to be additive throughout the state.

The measures of willingness to pay for improved water quality throughout this report were based on the premise that all waterways in the River Basin would be cleaned up by 1983 and then maintained in a clean state indefinitely. If circumstances such as postponement of environmental quality objectives resulted in delaying the improvement of water quality in the River Basin to the year 2000, the proportion of respondents willing to pay some amount of additional sales tax for improved water quality to enhance recreation enjoyment would decline by 11 percent. If it is not possible to improve water quality in the River Basin until the year 2000, annual willingness to pay for recreation use would fall by an average of $10.51 per household or 17.4 percent.

As pollution levels increased, willingness to pay for improved water quality increased more than proportionately. Improving polluted water to an intermediate quality level accounted for 63 percent of total recreation benefits from clean water in Fort Collins and 74 percent in Denver. This is the willingness to pay for enhanced recreation use, as respondents were not asked for the value of option, existence and bequest demands attached to an intermediate level of water quality. With only three data points, it would be heroic to generalize about the nature of the slope of the benefit curve for water quality improvement. The average values suggest that recreation use benefits from water quality improvement increase at a decreasing rate.

The hypothesis that size of city may affect the willingness to pay for improved water quality was not supported by this study. There was no significant difference in the recreation use value and option value reported in the two cities at the 95 percent confidence level.

The expectation that recreationists would be willing to pay more than non-users for improved water quality was not supported by this study. The relationship between the number of water-based recreation activity days annually in the South Platte River Basin and willingness to pay for improved water quality was not significant at the 95 percent confidence level. Average values suggest that the relationship may have been curvilinear. As recreation activity increased from zero to 21 days annually, average water quality values also tended to increase. Over 21 days annually, water quality values fell off. However, the tendency was not always consistent. The average option value of water quality increased continuously over the entire range of recreation use, but changes in value were not statistically significant.

Income was positively related to willingness to pay for improved water quality. Level of household income was significant at the 5 percent level in the regression analysis of variables associated with the value of improved water quality for recreation use. For example, in Fort Collins a $1,000 increase in household income was associated with a $3.66 increase in willingness to pay a sales tax for improved water quality. Regression analysis showed a significant positive relationship between household income and option value of water quality, in both cities, as measured by willingness to pay additional sales tax. However, in Fort Collins, there

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was a negative correlation between household income and option value of water quality, as measured by willingness to pay additional water bill. A higher proportion of Fort Collins residents engaged in water-based recreation activities outside of the River Basin than did Denver residents.

Where people work and the type of work they do had a significant effect on the value of improved water quality for recreation. Employees of small business and government were willing to pay more for water quality than either employees of large business and manufacturing or unemployed persons. The lowest values were among the retired. Employees of small business in Denver were willing to pay $25.08 more sales tax for improved water quality. Government employees were willing to pay $28.44 more than respondents working in the private sector. In Denver, professionals and business owners and managers valued water quality for recreation use by $21.67 per year less than other occupations. Retired residents valued water quality for recreation use by $30.03 less than those who remained active in the work force.

Whether the respondent was male or female had a significant effect on willingness to pay to improve water quality for recreation use. For example, men were willing to pay $26.55 more for water quality than women in Denver. The primary reason may have been that men engage in water-based recreation activities more than women, particularly fishing and to some extent boating. Apparently women who worked outside the home were particularly reluctant to allocate more of their income to sales taxes for improved water quality because housewives who remained in the home were willing to pay $20.91 annually more than those employed in other occupations, whether male or female.

Number of children in the household was not significant at the 5 percent level in the regression of variables associated with the value of improved water quality for recreation use. However, there was a significant relationship between number of children per household in Fort Collins and the option value of water quality. As the number of children in Fort Collins households increased, option value decreased by $10.45 per year.

Education level may be associated with more concern about the future of water quality than with current recreation use. There was a positive correlation between level of education and option value of water quality in Fort Collins. The relationship was significant at the 5 percent level. However, education was not significant at the 5 percent level in regression analysis of factors explaining the value of improved water quality for recreation use.

Age may be associated with less concern about the future of water quality, while concern about current recreation use is not associated with age. Older people were less concerned with preserving their option to engage in water-based recreation activities in the River Basin in the future. For example, willingness to pay a water bill declined by $6.60 with each 10 year increase in age of Denver respondents. However, age of

respondent was not significant at the 5 percent level in regression analysis of factors associated with the value of improved water quality for current recreation use.

Permanance of residence was a significant variable in regression analysis of variables associated with the value of improved water quality for recreation use. For example, Denver residents were willing to pay $3.40 less water bill for each 10 years they lived in the city. This appears contrary to the expected effects of permanence of residence on community pride, preservation of neighborhoods, and a quality environment. Recently arrived residents were willing to pay more than residents of 11-20 years and 21-40 years. Thus, the immigration of young adults into the state in the past decade may have increased the value of improved water quality.

Reasons given for moving to the River Basin were not significant in regression analysis. However, average values suggest that residents who immigrated to the River Basin for environmental reasons may value water quality more highly than those who came for other reasons. This would be consistent with the widespread belief that many people move to Colorado because of its reputation for a quality living environment.

Size of former residence was significant in regression analysis of variables associated with the recreation use and option value of improved water quality. For Denver residents, the smaller the place of former residence, the more they tended to value water quality. Having developed an appreciation for the natural environment in rural areas, they may place special emphasis on preserving it for recreation use in the future. For residents of Fort Collins, regression analysis shows the larger the place of former residence, the more they valued water quality. Perhaps those who are willing to pay more for improved water quality tend to migrate to smaller cities which have recreation resources nearby, while those who are less willing to pay for water quality remain in or move to large cities.

The bidding game technique was successful in meeting the objective of valuing the benefits of improved water quality. Bidding game techniques have been successfully used as a research tool for valuation of air quality in the past. The technique appears appropriate for valuation of a wide variety of non-market goods including water quality. It should be remembered, however, that bidding games measure the hypothetical responses of individuals faced with hypothetical situations. Thus, considerable care must be exercised in the design of bidding games and the conduct of surveys, to ensure the results obtained are as realistic as possible

SECTION 1

INTRODUCTION

BACKGROUND AND SCOPE OF STUDY

This study is an attempt to analyze and quantify recreational and aesthetic benefits accruing to society from the control of water pollution.[1/] Improving the estimation of benefits from pollution control programs is one of the more challenging aspects of applied benefit-cost analysis. Determination of willingness to pay for recreational and aesthetic attributes of improved environmental quality has proven to be a difficult aspect of an already complex problem. In addition to the usual difficulties encountered in measuring the value to society of a recreation user good where market transactions are absent, the benefits from pollution abatement may include significant "option," "existence" and "bequest" components. The primary contribution of this study will be to empirically test the importance of these latter values relative to the conventional user value. However, as noted above, measurement of the non-market and rather abstract values such as "option," "existence" and "bequest" requires careful development of a methodology which allows the assessment of the worth of such attributes of water pollution abatement to members of the appropriate populace.

Krutilla [1967] noted several possible instances of willingness to pay for environmental conditions which were distinct from the direct or immediate benefits to users of the environment. These additional contributors to the worth of a natural environment Krutilla termed "preservation benefits." Because this study concentrates on the development and implementation of a procedure for measuring these "preservation benefits" it is appropriate to carefully delineate just what will be measured at the outset.

Option value has been the subject of considerable controversy among economists. This study will utilize a definition and model developed by Henry [1974]. Option value is taken to mean the premium that individuals would be willing to pay to preserve irreplaceable environmental resources

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[1/] A complete economic analysis of a proposed pollution control policy would attempt to measure (a) the benefits of pollution control, (b) the costs of reducing or removing waste discharge, (c) the costs of monitoring and enforcement of regulations, and (d) where chronic unemployment exists, the indirect or secondary benefits and costs. A feasible policy is one for which the incremental benefits exceed the incremental costs [Kneese and Schulze, 1975].

now, in order that at some future date, when the necessary information affecting their decision whether or not to preserve the environment is available, they can at that time make the decision. It should be noted that this construct is quite different from earlier notions of option value. Existence value is simply the willingness to pay for the knowledge that the natural environment is preserved. Bequest value, which seems closely related to existence value, is the worth to present generations from preserving the environment for future generations.

Pollution of a river or lake to the extent that it diminishes the satisfaction of some individuals is a damage and improved water quality is a benefit. Improvement in water quality which reduces this kind of external cost is a non-market product, since it is non-exclusive, and a public good since it is inexhaustible at least over a substantial range. That is, more consumers of this kind of environmental improvement can be added without diminishing the aesthetic appreciation and recreation use of the resource available to each individual. Additional beneficiaries can be added at near zero marginal cost over a substantial range.

Bradford [1970] has presented a conceptual framework for the valuation of public goods. Traditional demand curves are inappropriate for the analysis of demand for public goods, since the situation is not one of individuals responding to a price per unit by choosing an appropriate number of units. Rather, the individual directly arrives at the total value to himself of various given packages. In the case of a public good, the individual is unable to exercise any choice over the quantity provided him, except as a member of the group of residents of a river basin which make a social choice. The nature of a public good, such as water quality improvement, is that increases in the quantity provided are not purely quantitative increases, but are more in the nature of improvements in quality. Thus, the individual compares alternative packages of a public good, which may differ in quantity and quality [Randall, 1974].

OBJECTIVE AND PLAN OF STUDY

The primary objective of this study is to develop and apply a procedure for analyzing the benefits of improved water quality to both recreational users of the resource as well as non-users. The South Platte River Basin, located in northwestern Colorado was selected as the site for a case study. A random sample of 202 residents of Denver and Fort Collins were interviewed in their homes in the Summer of 1976.

Specific objectives are:

1. Develop a conceptual framework and empirically test its application in the measurement of benefits of water quality improvement. Benefits to be measured include:
   a. Consumer surplus from enhanced enjoyment of water-based recreation activities;
   b. Option value of assured choice of recreation use in the future

by avoidance of irrevocable pollution by mineral and energy development, and

c. Existence and bequest values for non-users.

2. Identify the relationship between these values and the quality of water available as measured on a 3-point scale from low to high.
3. Test statistically the relationship between the expressed values of improved water quality and socioeconomic variables including income, degree of urbanization, education, age, occupation, amount of water-based recreation, and family size.

A review of previous research shows that a number of studies have been completed on question 1a of this study, recreation user benefits from water quality improvement. No empirical estimates, to our knowledge, have been developed on objective 1b, option value, and only one study of objective 1c, the value associated with preservation of the existence of a natural ecosystem and its bequest to future generations. Davidson, Adams and Seneca [1966] related unimproved and improved water quality to recreation participation in boating and fishing in the Delaware Estuary. Improved water quality resulted in an additional 8.7 million discounted activity days of boating and about .9 million days of fishing. No empirical estimates of dollar values were developed. Willeke [1968] related water quality improvement to recreation participation at San Francisco Bay, California. Ditton and Goodale [1972] showed the relationship between water quality improvement and recreation participation by residents of Green Bay, Wisconsin. Stevens [1966] and Stoevener, et al. [1972] related water quality and angler success to participation in fishing on the Yaquina Bay, Oregon. Based on a travel cost procedure, the sport fishery was valued at $22,747 annually. Reiling, Gibbs, and Stoevener [1973] related unimproved and improved water quality to recreation participation with benefits to recreation users and regional economic development at Klamath Lake, Oregon. The demand function for recreation was estimated using travel cost approach. Direct and indirect benefits of improved water quality were estimated as $2.6 million. An Environmental Protection Agency draft report [Abel, Tihansky, and Walsh, 1975; Walsh, 1977] estimated the national damages to fishing, boating, and swimming from water pollution levels in 1970. Extrapolation of previous information on recreation participation and travel costs resulted in a damage estimate ranging from $69 per household in travel costs to $115 per household including costs of travel and time at $2 per hour. Ericson [1977] interviewed a random sample of 141 visitors to Rocky Mountain National Park in Northcentral Colorado during the Summer of 1973. Willingness of tourists to pay for improved water quality to enhance enjoyment of water-based recreation activities averaged $5.55 per day of recreation. Oster [1977] interviewed 200 residents of the Merrimack River Basin in New Hampshire and Massachusetts reporting they were willing to pay $12 per person annually for improved water quality in the River Basin. Meyer [1974] interviewed a sample of residents of the Fraser River Basin, Vancouver, Canada concerning the value of preserving salmon in a natural river environment. He reported average preservation values of $223 per household annually.

The remainder of this report is organized into five sections. We outline the conceptual framework in Section 2 and describe the research procedures used in the analysis in Section 3. The empirical findings with respect to the user and non-user values of improved water quality are presented in Section 4. Section 5 presents the relationship between willingness to pay for improved water quality and socioeconomic variables. The appendix contains the sources of literature, the questionnaire, and the statistical results of regression analysis.

SECTION 2

CONCEPTUAL FRAMEWORK

REVIEW OF THE THEORETICAL LITERATURE ON OPTION VALUE

The origin of the concept of option demand may be traced to an article by Weisbrod [1964]. The formulation was an attempt to rebut Friedman's [1962] advocacy of the extreme case of cutting down the redwoods in Sequoia National Park. Weisbrod set forth two conditions for the presence of option demand: (1) infrequency and uncertainty of demand for the commodity under consideration, and (2) prohibitively high cost in time or resources of renewing production of the commodity once it has been curtailed. Visits to Sequoia National Park are usually infrequent and uncertain. Should production of the magnificent forests be diverted from aesthetic enjoyment to lumbering, it would require centuries for the forest to become reestablished. The opportunity cost of lumbering would then be the aesthetic enjoyment foregone.

Weisbrod's analysis began with a simplified problem for which he assumed that a market exists for the collection of an admission fee from all users to the park. It was further assumed that the park is privately owned by a perfectly discriminating monopolist whose present value of total costs exceed present value of total revenues. All external economies were assumed away, the product was considered non-storable, and the possibility of purchase before consumption was precluded. Given the foregoing propositions, if the private and social rates of discount are equal, then based solely on grounds of economic efficiency the park should be closed. Its productive resources should be reallocated to other uses.

Even so, Weisbrod contended that it may be unsound from society's standpoint to reallocate the park's resources. Given the presence of "economic men" who anticipate possibly visiting the park, but who are uncertain and in actuality may or may not make such a visit, they will be willing to pay a fee for an option which would guarantee their access to the park in the future. If a private market existed whereby this "option value" could be collected then it would influence the entrepreneur's decisions. However, without the option market, aggregate user fees would understate the total worth of the park to society. If in fact the park closes as a consequence of a lack of a practical way to collect the option value, the option demand of potential future users is unfulfilled.

Weisbrod emphasizes the fact that option value is significant for economic decision makers only when a decision to close the park is imminent. As long as the park remains open the provision of the option is a costless by-product of current operation. It fulfills the conditions of a pure

collective good since all potential future users of the park can maintain the option without enfringing on the consumption opportunities of others.

Other examples, cited by Weisbrod, where option value might exist are hospital service and public urban transit, which often meet the criteria of infrequent and uncertain demand and high production costs of reestablishing service once ended. In generalizing, Weisbrod explains that infrequency and uncertainty, and the high cost of re-initiating production are relative concepts and hence all goods probably have option value. The more frequent the purchase and the smaller the cost of re-introduction of a commodity the smaller will be the significance of option demand.

Following Weisbrod's introduction of option value, a debate ensued as to whether it was a totally new concept or merely "the unrecognized son of that old goat, consumer surplus" [Long, 1967]. Long attempted to show that option value was nothing more than "the expected consumer surplus from consuming the good at the terms specified in the option." He used Lerner's measure of consumer surplus as ". . . how much money a consumer would pay for the right to continue to buy at the current price something that he is now buying." He pointed out that the difference between his concept and Weisbrod's is that consumers under the latter definition may never use the option to purchase a commodity. The key to reconciling the two definitions according to Long, is recognizing that the terms specified in the option will have a significant effect on option value.

Given a typical Marshallian individual demand curve, consumer surplus would normally be defined as the area under the demand curve and above price. According to Long, if price is a positive amount, option value will be of a smaller magnitude than if price is zero. If price should rise further to a level that the individual would never purchase the commodity because of its prohibitively high price, then no option fee would be paid to preserve future access to the good. Since option value is a fee paid for <u>future</u> access, Long concludes that option value is simply expected consumer surplus from consuming the commodity at the specified price.

Long contends that divisibility and homogeneity are the important concerns of option value and not frequency of use as Weisbrod indicated. In Long's view, option value attains significance only when discrete change in product must be made and no good substitute exists, rather than for marginal changes necessary for efficient resource allocation. Weisbrod's high cost condition then becomes unrelated to the problem. Long concludes that introducing option value into economic analysis would serve only to inflate measures of demand for public goods.

Lindsay, [1969] takes exception to Long's contention that "option value is exactly the expected consumer surplus from consuming the good at the terms specified in the option" [Long, 1967]. He points out that Long ignores Weisbrod's initial assumption of uncertainty of consumption

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and implicitly substitutes certainty. Yet, as Lindsay explains it would be nonsensical to purchase options for future consumption for goods which the consumer knows with certainty he will or will not purchase. But since uncertainty pervades the future, many consumers may wish to pay a premium to insure against the risk of not having the commodity available.

The debate continued with comments by Byerlee [1971] and by Cicchetti and Freeman [1971]. Byerlee formulated the issue in mathematical terms which up to this point had been missing. Using a game theoretic framework, Byerlee established that under conditions of certainty of consumption that option demand was equivalent to consumer surplus. He further argued that where uncertainty of demand exists, option value as defined by Weisbrod can be shown to be greater than, equal to, or less than consumer surplus. He concludes that, as Long had suggested, including both consumer surplus and option demand would be double counting. He supports a modification of Lerner's definition of consumer surplus to include "how much money a consumer would pay for the right to buy at the current price something that he is now buying or may buy in the future" [Byerlee, 1971].

Cicchetti and Freeman countered Byerlee by suggesting that along with uncertainty in demand, uncertainty in supply must also be considered. Possible deterioration of the natural amenities of the site must threaten the continuance of supply for option demand to become relevant. This was a condition specified by Weisbrod, which Byerlee neglected in his statement of the probability of option demand. Cicchetti and Freeman used probabilistic demand theory to illustrate that a risk-averse individual will be willing to pay a positive amount, to preserve his option of using a facility in the future, when there is a threat to an irreversible consequence to the natural environment. Cicchetti and Freeman then argue for the inclusion of a risk premium to be added to consumer surplus derived from recreational enjoyment of the site.

Schmalensee [1972] disagrees with the approach used by Cicchetti and Freeman. He considers a state-preference model in a timeless world. Under the assumption of the model, Schmalensee attempts to show that risk from either alternative use of a natural environment must be considered. There is an associated risk if demand for recreation greatly increases in the future (present non-users opt to recreate at the site in the future) and the natural environment is not saved for recreation enjoyment.

Schmalensee points out that the other alternative must also be considered. If the natural environment is preserved there is a risk associated with a very small future demand. Society may desire products which cause pollution of a site more than it desires recreation. The opportunity cost of preservation becomes very great. It is argued that the magnitude of each alternative risk determines whether option value is positive, negative or zero. If the development alternative is riskier, then option value is positive. Should the preservation alternative prove riskier then option value is negative. With no way of measuring the sign or

magnitude of the associated risk premiums, Schamlensee regards expected consumer surplus as an adequate approximation of society's option values.

Henry [1974] suggests that Schmalensee's "timeless world" assumption where an individual can make but one irreversible decision (one decision is as irreversible as another) reduces option value to "a risk premium in favour of 'irreplaceable assets'." Henry proposes a "sequential world" model where decisions must be made by the individual at appropriate intervals. In so doing, Henry adds to our conception of option value. The principle changes from paying to preserve the possibility of using an unspoiled environment, to paying for preserving the <u>option</u> of deciding later on the two alternative uses of the environment when conditions of certainty will exist. Henry's model serves as a theoretical basis for the empirical measurement of option demand in this study. A fuller presentation of the theory is provided below.

AN EMPIRICALLY TESTABLE FORMULATION OF PRESERVATION VALUES

Option Value and Irreplaceable Environments

The lengthy debate surrounding the economic delineation of option value apparently has been laid to rest. Two recent articles published at about the same time show that option value may exist without the side condition of risk aversion motivating an individual. If there is a prospect of better information forthcoming relating to alternative uses of an asset with irreplaceable characteristics a situation arises where a positive option value may be generated.

Arrow and Fisher [1974] formulated a quasi-option value model developed in terms of aggregate benefits and costs of alternative environmental action. They questioned whether or not the existence of option value for the individual necessarily leads to a similar situation for society. They concluded that even in the aggregate society must take cognizance of the presence of option value.

The Henry [1974] model, adopted for this study, was presented in terms of willingness to pay for the option of choosing between two environmental alternatives at some future date under conditions of perfect information.

Consider a two period model with the following defined symbols:

N = The N-th individual
U = N's utility function
Y = N's income
CS = N's consumer surplus generated from use of the natural environment
D = Availability of the natural environment
D = d, the natural environment is available
D = d*, the natural environment has been appropriated for an alternative use and is not available
OV = Option Value
i = States of the world, i = 1, 2
P_i = Probability that state i will occur
j = Time period, j = 1, 2
C^j = Opportunity cost to retain the natural environment

The postulated model is based on the following assumptions: (1) the future is uncertain, (2) one use of the natural environment is more irreversible than the other, (3) a decision is imminent as to which use the natural

environment will be put and (4) sequential decision making takes place based on better information acquired through time. Let

$$U = \sum_{j=1}^{2} \sum_{i=1}^{2} P_i^j \, U_i^j(Y_i^j, D^j) \qquad (1)$$

(where $\Sigma P_i = 1$, for $j = 1, 2$)

be N's two period probability weighted utility function. Assume an opportunity cost C^j must be paid to obtain $D^j = d$, that is, a cost is imposed in the form of foregone alternatives if the natural environment is to remain available. C^1 and C^2 must be financed at instant 1 and instant 2, respectively if $D^j = d$ is chosen. For simplicity of exposition C^j and Y^j are assumed known with certainty.[1/] Finally assume that

$$\sum_{i=1}^{2} P_i^1 \, U_i^1(d) < \sum_{i=1}^{2} P_i^1 \, U_i^1(d^*) \qquad (2)$$

This assumption specifies that if only the first period is considered, N will choose d^* so that the natural environment is not available. In this case the cost, C^1, of preserving the natural environment is greater than the associated benefits in period 1.

In the following case no new information is expected to become available between instant 1 and instant 2. A decision is made as if a "timeless world" existed. Consumer surplus for N can be defined as the equating factor in:

$$\sum_{i=1}^{2} P_i^1 \, U_i^1(Y^1 - CS, d) + \sum_{i=1}^{2} P_i^2 \, U_i^2(d) = \qquad (3)$$

$$\sum_{j=1}^{2} \sum_{i=1}^{2} P_i^j \, U_i^j(d^*)$$

The equation simply states that N will be willing to pay an amount CS at instant 1 to have d.

[1/] The notation may then be simplied to

$U_i^j(Y^j, d^*) = U_i^j(d^*)$ and in later equations, $U_i^j(Y^j - C^j, d) = U_i^j(d)$.

Even after payment of the amount CS, the individual will still receive the same expected utility as if the natural environment were not available.

Note that N will choose the preserved natural environment as opposed to the development alternative if $CS > C^1$. No CS term need appear in the second period term of the preservation alternative since no change in information occurs between the two periods. As long as C^1 is paid at instant 1 the natural environment will be available in all following periods because of the static situation. In this case CS is the present worth of N of the preserved natural environment for all time.

Now assume that new information enters between instant 1 and instant 2. Individual N will know with certainty at instant 2 which state of the world will obtain. Allowing for a sequential decision making process to take place the following question must be answered: How much will N be willing to pay at instant 1 to (1) enjoy the natural environment through period 1 and (2) to have the option of choosing under conditions of certainty at instant 2 whether or not to retain the natural environment?

The preceding question can be answered by referring to the following equation:

$$\sum_{i=1}^{2} P_i^1 \, U_i^1(Y^1 - CS^1 - OV, d) + \sum_{i=1}^{2} P_i^2 \max \{U_i^2(d), U_i^2(d^*)\} = \sum_{j=1}^{2} \sum_{i=1}^{2} P_i^j \, U_i^j(d^*). \tag{4}$$

The terms CS^1 and OV are the balancing factors in equation (4). At instant 1 individual N will be willing to pay CS^1 to enjoy the natural environment during period 1. In addition N is willing to pay an amount OV to choose, at instant 2, either the preserved environment or the development alternative with full knowledge of which state of the world will obtain. In equation (4) CS^1 results from the enjoyment of the preserved natural environment through period 1 only.

Note that the magnitude of OV in period 1 is a function of the magnitudes of P_i^2, $U_i^2(d)$ and $U_i^2(d^*)$ in period 2 as they exist at instant 1.

In considering the term $(\max \{U_i^2(d), U_i^2(d^*)\})$ four possible cases can occur:

(a) $U_1^2(d) > U_1^2(d^*)$ and $U_2^2(d) < U_2^2(d^*)$

(b) $U_1^2(d) < U_1^2(d^*)$ and $U_2^2(d) > U_2^2(d^*)$

(c) $U_1^2(d) < U_1^2(d^*)$ and $U_2^2(d) < U_2^2(d^*)$

(d) $U_1^2(d) > U_1^2(d^*)$ and $U_2^2(d) > U_2^2(d^*)$

If, for example, situation (a) evolves then:

$$\sum_{i=1}^{2} \left[P_i^1 U_i^1(Y^1 - CS^1 - OV, d)\right] + P_1^2 U_1^2(d) + P_2^2 U_2^2(d^*) = \tag{5}$$

$$\sum_{j=1}^{2} \sum_{i=1}^{2} P_i^j U_i^j(d^*)$$

The inequality:

$$P_1^2 U_1^2(d) + P_2^2 U_2^2(d^*) > \sum_{i=1}^{2} P_i^2 U_i^2(d) \tag{6}$$

exists because maximum values of $U_i^2(d)$ and $U_i^2(d^*)$ were chosen. Therefore OV > zero and d will be chosen at instant 1 if $CS^1 + OV > C^1$. The magnitude of OV is determined precisely by the difference between the right and left-hand expressions of inequality (6). In cases (b) and (c) OV will likewise be positive. Only in case (d) will option value be equal to zero. None of the four possible situations will produce a negative option value.

Option value is irrelevant to the decision-making process as long as $CS^j > C^j$. Here the option to use the environment in the future has been preserved free of cost. The option is a free by-product as long as the user benefit of the preserved environment exceeds the opportunity costs of preservation. It is for this reason that inequality (2) is required. This expression states that if the first period is considered by itself, development is preferred over conservation. Under this condition it is necessary to include explicit consideration of the second period in order to determine the proper course of action at the beginning of period one.

An empirically derived estimate of OV is provided in this study. To meet the assumptions of the model the future was assumed uncertain, a reasonable assumption for the survey participants. The real threat of expanding coal and metal mining operations were assumed to have irreversible consequences for rivers and streams in the South Platte River Basin. This irreversibility results from the prohibitive costs of pollution abatement from non-point sources. Finally, better information as to which use of the River Basin would be more beneficial to the individual was assumed to be forth-

coming in the future. Respondents were asked what they would be willing to pay now for the option of making a choice in the future with better information available as to whether preservation or mining development would benefit them more.

Existence Value

There exists no rigorous definition and theory of existence value. It has been defined as the amount an individual would be willing to pay to preserve an area as a natural habitat for the satisfaction provided by the knowledge that such an area exists.

Krutilla [1967] provided a brief introduction to the possibility of existence demand:

> There are many persons who obtain satisfaction from mere knowledge that part of wilderness North America remains even though they would be appalled by the prospect of being exposed to it. Subscriptions to World Wildlife Fund are of the same character. The funds are employed predominately in an effort to save exotic species in remote areas of the world which few subscribers to the Fund ever hope to see. An option demand may exist therefore not only among persons currently and prospectively active in the market for the object of the demand, but among others who place a value on the mere existence of biological and/or geomorphological variety and its widespread distribution.

Discussion of existence value is also found in a later work by Krutilla and Fisher [1975]. Essentially the same arguments are made to support the case for existence value.

Existence value like option value attains relevance only when there is an imminent danger to a natural environment. Otherwise it serves as a pure public good, free to all as long as the area is preserved. No one can be excluded from the satisfaction which is derived from the area's existence.

Although an individual may not physically use a natural environment the knowledge of its existence acquired vicariously provides utility to him. Let Q be defined as a preserved natural environment serving as a native habitat for fish, plant and animal life. Knowledge of the existence of this environment is defined as K. Then $K = f(Q)$. This means that the natural environment Q is providing the "service" of existence, knowledge of which yields satisfaction to the individual. A similar service provided by the area may be the aesthetic appreciation and enjoyment derived from hiking through the natural setting. One essential difference between the two services is that the latter is provided "on site" while in the former case one need never set foot in the area to gain satisfaction derived from the knowledge of its existence. Since $K = f(Q)$ the satisfaction from

existence knowledge is dependent on the physical preservation of Q. The reasonable assumption is made that the nearer the area is to being a natural pristine setting (as opposed to a degraded environment) the greater will be the magnitude of existence value. Willingness to pay for existence knowledge must be added to recreational use benefit estimates for a preserved natural environment or an underestimation of such benefit estimates will result.

For the purposes of this study, empirical measurement of existence value was undertaken within the guidelines outlined by Krutilla. That is, it was assumed that bona fide non-users of the South Platte River Basin possessed satisfaction from the knowledge of existence of the preserved environment. There appears to be no a priori reason why users as well as non-users should not have an existence value for the South Platte River Basin. Once the presence of existence value is established it should be quite an easy matter to extend the empirical estimation process to users of the natural environment. Willingness of users to pay for knowledge of existence could, in some instances, exceed that of non-users since they have acquired first hand experience and appreciation of the preserved area.

Survey respondents in this study were asked what they would be willing to pay for preservation of the South Platte River Basin knowing that it would be available as a natural habitat for fish, plant and animal life, even though it were certain they would not use the area fro recreation in the future. The question was designed so that an estimate from a sub-sample of non-users could be made. Non-users were defined as those whose probability of future recreational use of the South Platte River Basin was zero. Benefits to the non-user population were approximated from this sub-sample.

Bequest Value

An additional type of non-user benefit has been suggested by Krutilla [1967]:

> We are coming to realize that consumption-saving behavior is motivated by a desire to leave one's heirs an estate as well as by the utility to be obtained from consumption. A bequest of maximum value would require an appropriate mix of opportunities to enjoy amenities experienced directly from association with the natural environment along with readily producible goods. But the option to enjoy the grand scenic wonders for the bulk of the population depends upon their provision as public goods.

Bequest value is the satisfaction derived from endowing future generations with a natural environment. In many respects it is similar to existence value. Little work has been done theoretically or empirically on this concept. Although the bequest motivation means that non-users may also have a desire to preserve natural environments, there is no a priori

reason that users could not likewise have such a desire with an appropriate value. Bequest value may actually be greater for users than non-users as they have firsthand knowledge of the environment.

Bequest value is a pure inter-temporal public good. Members of the present generation will be in a position to provide a bequest of a natural area to future generations so long as its remains preserved. If there is a threat to the area's preservation, bequest value takes on greater significance. Bequest value then is no longer a free service of the environment. It must be estimated along with use values of the environment to attain an accurate estimate of the total benefits of the preserved area. The total value of the natural environment to society may be underestimated and a serioues misallocation of resources could result if bequest values are ignored.

As in the case for existence value, bequest value in this study was conservatively measured only for individuals who did not use the natural environment. Non-users were defined as those who probability of future use was zero. Respondents were asked what they would be willing to pay to bequest improved water quality in the Souht Platte River Basin to future generations if it were certain they themselves would not use it for recreation in the future. A sub-sample of non-users was drawn to estimate the aggregated benefits to the general non-user population of the survey area.

It should be restated that as long as there is no threat to the natural environment by a competing use (e.g., metal and energy development), then option, existence and bequest values are provided as a free public good to all who possess such satisfaction. If circumstances change so that there is a significant possibility of a competing use occurring, such values may attain great importance for society. The total value of all alternative uses of the environment must be ascertained to enable society to make the correct decision as to which use it should be put.

SECTION 3

RESEARCH PROCEDURE

STUDY AREA

The South Platte River Basin drains an area of 19,450 square miles in northwestern Colorado, approximately one-fifth of the total land area in the state of Colorado (Figure 1). It extends from the Continental Divide on the western edge to the Nebraska border on the east. It extends from a line just outside Colorado Springs on the south to Wyoming and Nebraska borders on the north. It encompasses an area known locally as the Northern Front Range of Colorado.

Streams originate in the higher mountainous elevations with pristine water quality, and gradually yield to degradation as elevation diminishes and human encroachment increases. There are some areas within the Basin even at high elevations where streams have become heavily polluted through past mineral mining and milling operation and abandoned shaft drainage. The Central City and Boulder Creek drainage areas are examples. Rocky Mountain National Park on the western edge of the River Basin contains the headwaters of the Cache La Poudre River, the Big Thompson River and the St. Vrain River, major northern tributaries to the South Platte River. The River Basin contains 2,400 miles of fishing stream, about 30 percent of the 8,233 miles of stream in the State capable of sustaining game fish such as trout.

With an estimated population of 1,742,900 in 1976, the River Basin contains two-thirds of Colorado's estimated population of 2,628,137. The Denver Metropolitan Area excluding Boulder County with population of about 1.3 million is representative of larger cities in the U.S. It is the principle commercial center of the Rocky Mountain Region. Manufacturing, service industries and government are important sources of employment. Agriculture is important economically with large cattle feeding operations, packing plants, irrigated and dryland crops. The 1969 Census of Agriculture showed approximately 10,158 farms in the South Platte River Basin. With an average family size of 4 persons, the farm population is estimated at 40,632 or 2.4 percent of the total Basin population. About 11.5 percent of the residents in the Basin live in areas of less than 2,500 people. A substantial portion of the crops produced in the Basin are irrigated. Most of the Basin east of the mountains is arid and irrigation is necessary for agricultural production other than wheat and grazing. More rainfall and snow occurs at the higher elevations, and runoff in the Spring is captured in reservoirs for agricultural and domestic consumption. Also, water is transferred into the region from the Western Slope of Colorado.

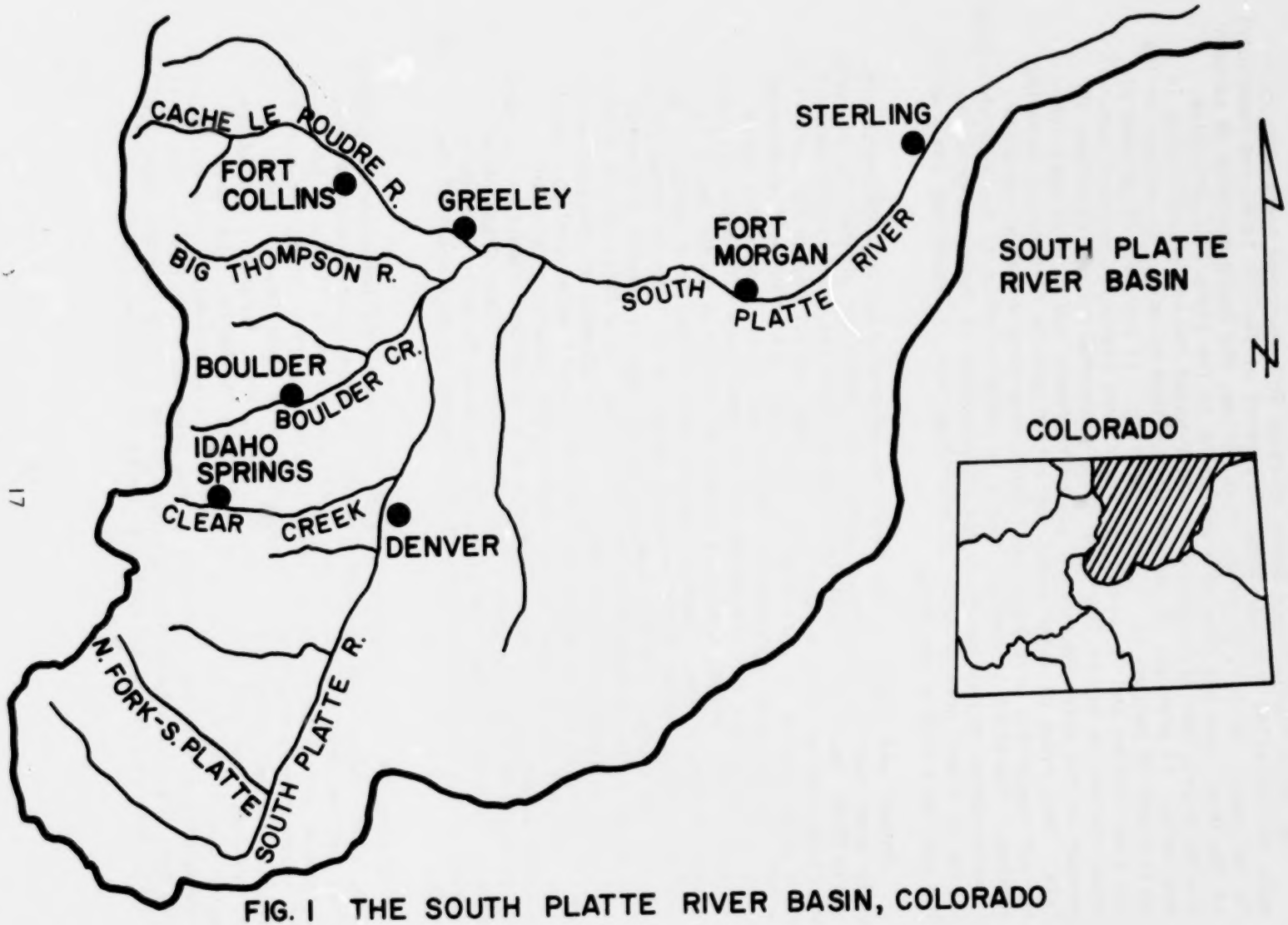

FIG. 1 THE SOUTH PLATTE RIVER BASIN, COLORADO

The South Platte River Basin contains 267 lakes and reservoirs suitable for shoreline fishing, about 38 percent of the 711 lakes and reservoirs in the state. With 1,122 miles of shoreline, the Basin contains 48 percent of the total lake and reservoir shoreline in the state of 2,314 miles. The Basin provides 40.5 percent of water-based recreation activities in the state. It provided 58 percent of the lake swimming, 56 percent of the sailing and 49 percent of the power boating. It provided 34 percent of the lake fishing and 26 percent of the stream fishing. Resident water-based recreation use of the River Basin accounted for approximately 72 percent of the total recreation use by residents and non-resident tourists. Many types of water-based recreation such as fishing and swimming are not compatible with water pollutants from mine drainage and other sources. Therefore if current demand is large relative to the available supply of water-based recreation areas the consequences of further degradation may be of a much greater order of magnitude than if demand was small while the available supply was large.

Streams and rivers in the Basin are generally out of compliance with state water quality standards. Almost all rivers and streams in the South Platte River Basin are classified Class B fisheries. Lakes and reservoirs are classified as Class A, suitable for body contact recreation activities. Major point sources of pollution are municipal and industrial discharges. In 1974 the Colorado Department of Health and local departments found 95 of approximately 120 discharges out of compliance with state effluent standards. The largest non-point source of pollution in the Basin is irrigation return flow. Feedlot run-off ranks second as a source of non-point pollution. Heavy metal effluent serves as an index of water pollution for the study. Although metal-mine drainage is generally limited to streams in the headwaters of the Basin there is a total of 111 miles of streams polluted with heavy metals. In the absence of complete water quality analysis and an objective index of overall water quality, heavy metal effluent serves well in representing the general problem of polluted waterways. It is estimated that a 90 percent reduction is heavy metals would be required before fish could live in Clear Creek above Denver. This particular form of pollution tends to be irreverisble because of the prohibitive costs of improvement in most areas of the Basin.

Mining activity is expanding with opening of the Henderson molybdenum mine, other newly found ore deposits and the opening of abandoned metal mines and new open pit coal mines. This expansion is likely to have a pronounced effect on the River Basin's water quality. There are more than 250 indentifiable minerals in the South Platte River Basin. Metallic minerals include gold, silver, copper, lead, zinc, tungsten, molybdenum and uranium. Two coal fields are located in the Basin. The Denver Region coal field is an area of 535 square miles extending from the Colorado-Wyoming state line southward to the Arkansas River Basin. The South Park coal field covers about 100 square miles in Park County. Over 3,682 million tons of coal is estimated to exist in these two fields.

SAMPLE SELECTION

A random sample of residents was selected from the Denver Metropolitan Area (as representative of residents of large cities in the U.S.), and from Fort Collins (as representative of residents of small cities in the South Platte River Basin). Fort Collins is smaller than Boulder but larger than other small cities in the Basin such as Greeley, Loveland, Fort Morgan and Sterling. Figure 1 shows the location of these communities in the River Basin.

A total of 202 in-depth interviews were completed in the two cities from May through July, 1976. The 101 interviews in Fort Collins represented a 0.5 percent sample of 18,923 households in that city. With a population of 58,531 in 1976, the average number of persons per household was 3.1. Boulder County was excluded from the Denver Metropolitan Area on the grounds that it is more representative of small cities in the River Basin. The 101 interviews in the Denver Metropolitan Area (less Boulder County) represented a very small proportion of the 424,900 households in that large city, approximately 1 in 4,200. The number of households interviewed was based on experience with similar opinion surveys and was specified in the contract with the Agency.

A list of names was randomly selected from current telephone directories for the two cities. For the Denver Metropolitan Area, one name was drawn randomly from every ninth page of the telephone directory. Two names were drawn randomly from every page of the directory for Fort Collins. Initially, an attempt was made to select the sample from city directories. However, at the time the sample was drawn, the directories were over one year old. Telephone directories were more up-to-date than city directories and this was considered important because of high mobility of residents in the two cities. By sampling from telephone directories, it is recognized that residents who moved into the cities within the year and residents without phone service were automatically excluded from the sample. However, it was concluded that the resulting bias in sample selection was small, as 92 percent of the households in the Denver Metropolitan Area had telephone service, as did 95 percent of the households in Fort Collins.

An initial list of potential respondents (392 in Denver and 208 in Fort Collins) was selected from the current telephone directory. Each household on the list was sent an introductory letter. The interviewers contacted respondents by telephone, proceeding randomly through the initial list until the pre-established quota of 100 for each city was interviewed.

Table 1 shows the rate of acceptance and refusal in the two cities. In Denver, 25.8 percent of an initial list of 392 households were interviewed, compared to 48.6 percent of a list of 208 in Fort Collins, a small city where Colorado State University is located. The refusal rate was small, 21.7 percent in Denver and 16.3 percent in Fort Collins. However, a large proportion of the sample could not be contacted although telephoned at least twice. Interviewers were unable to contact 42.1 percent of the sample

Table 1 . Sample Response in Denver and Fort Collins, Colorado, 1976.

Response	Denver Metropolitan Area		Fort Collins		South Platte River Basin	
	Number	Percent	Number	Percent	Number	Percent
Total Sample	392	100.0	208	100.0	600	100.0
Accepted and Interviewed	101	25.8	101	48.6	202	33.7
Refused	85	21.7	34	16.3	119	19.8
Could Not Contact	165	42.1	66	31.7	231	38.5
Returned Letters	41	10.4	7	3.4	48	8.0

in Denver compared to 31.7 percent in Fort Collins. In addition, returned letters accounted for 10.4 percent of the Denver sample and 3.4 percent in Fort Collins. The letters were returned by the Postal Service because they could not be delivered. These potential respondents had moved since publication of the directory and had no forwarding address.

Characteristics of the sample were compared with the available demographic characteristics of the population of the two cities. Generally, the relatively small sample represented the population rather well. For most comparisons, the sample statistic was very close to the population parameter. Table 2 lists the demographic data for the relevant population and sample.

The Metropolitan Denver sample under-represented young residents of 18-24 years of age. There is less chance of younger residents being listed individually in telephone directories. Often younger adults continue to live with their families where the listing is not in their name. If they are living independently of their families they are likely to be living in a shared household so that the listing may be under another individual's name.

Minorities including Spanish surnamed, black Americans and American Indians were also under-represented. A large percentage of minority residents with common surnames such as Martinez or Gonzales are concentrated on a few pages of the alphabetically listed directories. The selection procedures used in this study would result in an under-representation because of this phenomenon. It may also be true that fewer minorities have telephone service. Twenty percent of the population of the Denver Metropolitan Area were non-white as compared to 5 percent of the sample.

Average incomes were virtually identical for the sample and the population at about $15,000. Income distribution categories for the sample had slightly different brackets than the population data brackets; however, it appears that the sample included slightly more lower income people than in the general population. Average education of the sample at 14.6 years was higher than for the population, reported as 12.5 years in 1970.

Sample representation of the sexes closely approximated the population characteristics. In Fort Collins females were under-represented by about 10 percent. This was the result of a number of female family members requesting that their spouse provide the information for the survey. There was a reluctance on the part of these female family members to provide the survey information. In most of these cases the husband was the traditional family spokesman and the wife requested that he provide the necessary data.

The Fort Collins sample also under-represented young residents of 18-24 years of age. However, average age of the sample was 38 years compared to a 40.5 years average age of the population. Average education of the sample was 14.6 years compared to 12.6 years for population in 1970. Minorities represent about 9 percent of the population compared to only 1 percent

Table 2 . Comparison of Population and Sample Demographic Profile Estimates of Denver and Fort Collins, Colorado, 1976.

Statistic	Denver		Fort Collins	
	Population	Sample	Population	Sample
Male/Female Ratio[a] (1975)	49.5/50.5	48.9/51.1	53.1/46.9	63.3/36.4
Average Age[a](1970) (18 years and over)	38.2	46.5	40.5	38
Age Distribution[a] (1970)				
18-24	19.7	7.6	23.2	9.1
25-49	48.9	50	48.5	57.6
50-64	19.5	25.3	16.8	16.1
65 and over	11.9	17.4	11.6	17.2
Average Education[a](1970) (25 years and over)	12.5	14.6	12.6	14.6
Race[b] (1976)				
White	79.7	94.6	91.2	99
Other	20.3	5.4	8.8	1
Average Income	$14,647[a]	$14,958	$13,500[c]	$12,838
Income Distribution[a] (1975)				
(Under $5,000) (Under $6,000)	8.2	14.1	11.1	15.2
($5,000-$7,999)($6,000-$8,499)	8.0	8.7	13.5	10.1
($8,000-$9,999)($8,500-$10,999)	9.1	9.8	11.0	12.1
($10,000-$14,999)($11,000-$15,999)	26.5	22.8	25.9	31.3
($15,000 & over)($16,000 & over)	48.2	44.6	38.5	31.3

[a](Colorado Department of Health, 1976).

[b](Colorado Division of Planning, 1976).

[c]Estimate for the Fort Collins Metropolitan Statistical Area by the Department of Housing and Urban Development, Denver, December 31, 1976.

of the sample. Average income of the population was reported as $13,500 in December, 1976 compared to $12,838 for the sample taken in May - July, 1976. Income distribution of the sample conformed closely to income distribution of the general population with slightly more lower income people included in the former.

CONTACTING RESPONDENTS

The method adopted to contact potential respondents was successfully used in a previous study by Meyer [1974]. An introductory letter was mailed to respondents about seven days before they were contacted by phone. The introductory letter said they would be contacted and asked them to participate in a survey of attitudes toward the quality of water resources in the state. It stated that there was no obligation to cooperate in the survey but that those who did may influence future water quality decisions. A copy of the introductory letter is shown in the Appendix to this report.

The letter of introduction proved useful in identifying the University and added credibility to the survey. This was found to be quite important because of the many telephone sales schemes to which the general public are subjected. The seven days between receipt of the initial introductory letter and phone contact was an appropriate length of time in most cases. The potential respondents had sufficient time to discuss the letter with family members yet not so lengthy a time that contents of the letter would be forgotten.

Within approximately one week after mailing the introductory letter, interviewers began telephoning potential respondents. They were asked if they had received the introductory letter, and the credentials of the caller were reestablished in the memory of the potential respondent. For those who agreed to participate, a convenient time was arranged for an interview with the head of the household. The interviews occurred during the following five days. The proportion of potential respondents missing appointments rose appreciably as the scheduled time exceeded five days after telephone contact.

Two trained interviewers were used to minimize inconsistency of presentation. The interviewers had advanced training in economics of natural resources and environmental management at the Masters degree level. Close liaison was maintained between them throughout the survey process so that unanticipated procedural problems were solved as they arose. Interview time ranged from 15 minutes to 2 hours and averaged approximately one-half hour each. Approximately five interviews per interviewer were completed per day.

Relatively few problems were encountered during the survey. Most problems that did arise resulted from interviewing in a large metropolitan area such as Denver. It took more time in the large city to establish credentials and explain the importance of the study during the initial

phone contact. Also, there was no feasible way to survey one section of the city at a time and effort was spent traveling from one interview to another. Another problem encountered in both cities was an expressed lack of confidence in public entities to achieve improvement in water quality even if appropriate financing could be secured. Little confidence was expressed in the Denver Water Board, the State of Colorado, and Environmental Protection Agency and the Federal government by a significant number of participants. This problem may have led to more conservative bids then would otherwise be forthcoming. In some cases there was an expressed disapproval of one or both methods of financing improved water quality. Minor problems were also encountered with a few individuals who could not easily grasp financing water quality through one of the posited methods. Hence considerable time was expended in explanation.

At the time of the scheduled interview, an introductory statement established the credentials of the interviewer and the purpose of the survey. This was an informal paraphrase of the following:

> "Hello, I am _____ of Colorado State University in Fort Collins (hand respondent a copy of the introductory letter). A short time ago you received a similar letter in the mail. An appointment was made with you for this hour. This letter from the chairman of the Department of Economics briefly explains the purpose of the study and the importance of talking with people in households like yours throughout the (Denver) (Fort Collins) area. I want to find out how you feel about water quality. I am interested in your enjoyment from using and viewing rivers and lakes (fish, waterfowl, waterplants and the water itself), and your satisfaction in knowing such natural environments are preserved."

Then the respondent was handed a copy of the questionnaire shown in the Appendix and asked to read along with the interviewer. Any questions raised by the respondents were clarified by the interviewer. First, the respondent was asked to provide some common socioeconomic information such as age, place of former residence and income. Then, respondents were asked their opinions about general environmental problems and perceived water quality in the South Platte River Basin.

Immediately after the respondents were asked their opinion on how they rated the waterways of the South Platte River Basin in terms of quality (Question 11) they were shown a map illustrating the area encompassing the Basin. They were thus made familiar with the rivers and boundaries of the Basin. When such information was needed during the remainder of the interview to provide an appropriate answer the respondents were free to review the map.

Next the respondents were read the following introduction to water quality and associated problems in Colorado:

"Coal development along with expanding mining operations may have significant effects on the quality of Colorado's water in the near future. As an aid in planning for the future I would like to find out how you feel about clean water for recreational activities. I have some questions which consider different ways of financing improved water quality. Let us consider three levels of water quality in a waterway such as the South Platte River."

COLOR PHOTOGRAPHS

Then respondents were shown pictures of three levels of water quality illustrated in Figure 2 and technical data on heavy metal pollution shown in Table 3 . The three photographs depict three levels of water quality in the South Platte River Basin. The respondent was told that in Situation A, water pollution had been nearly eliminated and the waterway restored to its natural condition. Situation B shows considerable reduction in water pollution, but a greenish tint resulting from the presence of copper and other metals remains clearly visible. Situation C shows severe water pollution, with a heavy load of mining waste.

The interviewers pointed out the salient features of water pollution in each set of photographs. For most of the respondents, the situations were rooted in real experience. The residents of the River Basin are familiar with pollution of waterways by mine tailings as in Situations C and B. Situation B was a fairly good approximation of the Denver situation at the time of the interviews. The pristine water quality of Situation A is typical of several high mountain streams in Rocky Mountain Park and National Forests on the western edge of the River Basin.

Photographs were taken at river locations along the Colorado Front Range. The composition of photographs was held constant in so far as possible. Site C with the most pollution is located on California Gulch near Leadville. Although California Gulch is in the Arkansas River Basin drainage system, pollution at the site was equal to Clear Creek in the South Platte River Basin. By using this site colored water features related to mine drainage could be illustrated. Site B is an intermediate pollution situation. It is directly below the Henderson Molybdenum mine near Berthoud Falls. The site is located on the West Fork of Clear Creek. Site A, the cleanest of the three pictural sites is located on the Poudre River above Fort Collins.

Color photographs are realistic in depicting evidence of visual pollution such as algae, weeds and heavy metal coloration, but do not show non-visual pollution such as odor, nor the presence of chemicals and bacteria. Measures of heavy metal concentrations at the sites where the photographs were taken were available, and these were presented to the respondents as an example of one major source of water pollution.

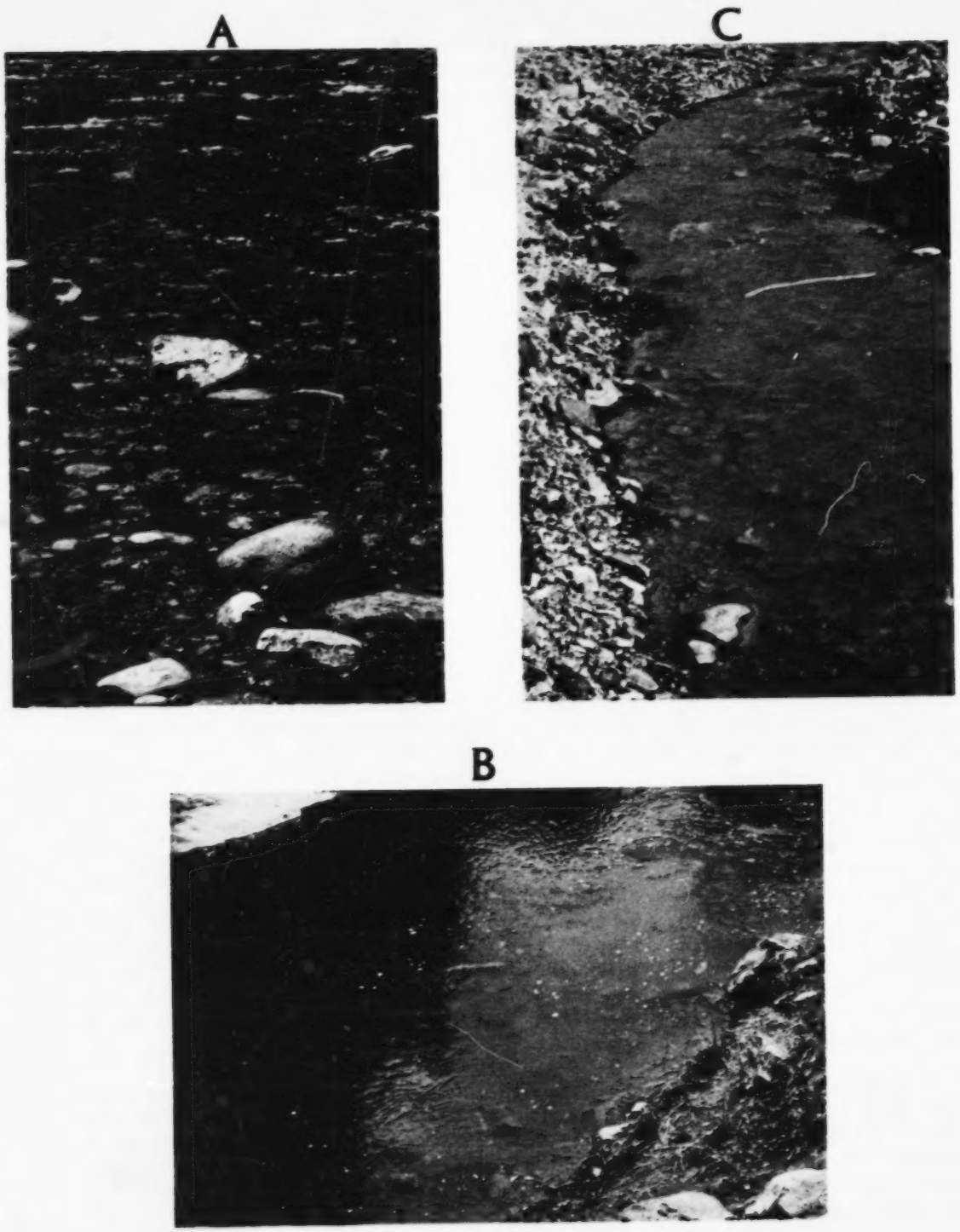

Figure 2. Three Levels of Water Quality, South Platte River Basin, Colorado, 1976.

Table 3 . Heavy Metal Pollution at the Three Photograph Sites, South Platte River Basin, Colorado, 1973.

Heavy Metals	Metal Concentration (Micrograms/Liter)			
	C	B	A	Recommended Biological Limits for Fish Survival
Arsenic	16*	-	-	1,000
Cadmium	620*	<10	-	10
Copper	2,000*	10	-	10-20
Iron	50,000*	380*	-	300
Lead	450*	<50	-	5-10
Magnesium	66*	1.4	-	-
Manganese	28,000	580	-	1,000
Molybdenum	-	1	-	-
Nickel	50	<25	-	50
Selenium	48*	-	-	1,000
Vandium	-	3.1	-	-
Zinc	100,000	90	-	30-70
Total Metals	181,250	<1,150.5	-	500

*Indicates these metalic concentrations exceeds recommended drinking water standards.

Source: [Wentz, 1974].

Water quality data for the three photograph sites are shown in Table 3. Metals associated with acid mine drainage are listed with the amount of each in micrograms per liter. An * indicates that the concentration exceeds recommended drinking water standards. Recommended biological limits for fish and wildlife communities are also shown. Site C exceeds concentration recommended for drinking water. Site B exceeds total metal concentrations recommended for fish and wildlife communities. No heavy metals were measurable at Site A by the sampling and analytical methods used.

METHOD OF PAYMENT

The bidding game process described in Section 2 was used to measure the respondent's consumer surplus in two separate simulated market situations. These situations were: a general sales tax and residential sewer-water bill. The methods of payment were chosen so as to maximize the realism and credibility of the hypothetical situation posited to respondents. Both approaches represent established, routinized methods of paying for public services. It was therefore not difficult for most respondents to comprehend the financing of pollution abatement by either approach.

Residents of both cities were familiar with the practice of paying a sales tax. For most it is a daily occurrence. People are aware that income collected in sales taxes is used to provide public services. It is realistic to conceive of a public agency collecting a sales tax and using the income to finance improved water quality. Respondents were asked to assume that a sales tax would be collected on all purchases in the South Platte River Basin for purposes of financing improved water quality in the region. This provision was designed to avoid the effects of the free-rider problem.

The sales tax measure of the value of improved water quality may be considered superior to the water bill in that tourists pay sales taxes as well as residents of the River Basin. Tourism is the third largest industry in the state with total sales of approximately $700 million in 1976. Tourism is an important source of revenue to state and local units of government. A 6 percent sales tax raises approximately $42 million annually in revenue from tourists.

Residents of both cities are familiar with the practice of paying for wastewater treatment through monthly water bills. Homeowners and renters realize that revenues collected through the water bill also provides sewer treatment services. Monthly water bills show the sewer assessment as a separate item, and sewer rates are based on water usage. Inadequate treatment of wastewater causes much of the water pollution in the River Basin. Most people can readily comprehend that reduction of the damage may raise the cost of operating sewer treatment plants, and that paying these additional costs through increases in the sewer-water bill is a distinct possibility. For the residents of small and large cities of the

River Basin, payment of a monthly sewer-water bill is routine. However, renters do not directly pay water bills, landlords do, so the sales tax is considered to have more general acceptance than a water bill.

Immediately preceding the commencement of the bidding game the respondents were shown a table with the annual amount of money in dollars that families in Colorado pay in sales tax as estimated by the Internal Revenue Service in 1975. Tax rates were shown for Internal Revenue Service income brackets and family size. The table showed the amount of money a family would pay with a 5 percent sales tax, the amount of state and city tax collected per dollar in Fort Collins. Denver residents pay 6.5 percent per dollar in sales tax and surrounding areas pay a varying amount depending on the particular suburb. The additional annual amount of money that would be paid through a one-quarter cent increment in sales taxes was shown and the total annual amount paid in sales tax was calculated for each respondent. Thus the respondent knows approximately how much money he presently paid in sales taxes along with how much additional money he would pay for every one-quarter cent increment in sales tax before the bidding game began.

BIDDING GAME

The bidding game procedure used in this study had been successfully applied to other natural resource value problems such as recreation use of forest areas and air quality [Davis, 1963, Randall, 1974]. It was employed here to determine willingness to pay for improved water quality to enhance recreation enjoyment, option, existence, and bequest values. Respondents were asked by how much they would be willing to increase their current sales tax in cents per dollar and water bill in dollars per month to pay for improved water quality in the South Platte River Basin. The sales tax bidding procedure began at one-half cent with one-fourth cent incremental changes upward or downward. The water bill bidding procedure began at 50 cents per month with 50 cents per month incremental changes.

For each bidding situation, respondents were asked to consider Situation C, the greatest degree of water pollution as the starting point. The bidding games were designed to discover the maximum amount of money which the respondent, an adult speaking for his or her household, was willing to pay to improve water quality to intermediate Situation B and the clean water of Situation A. Answers were given as "yes" or "no" to questions expressed in the following form:

> "Would you be willing to add one-fourth cent on the dollar to present sales taxes every year, if that resulted in an improvement from Situation C to Situation B?"

A "yes" answer would lead the interviewer to raise the amount by one-fourth cent and repeat the question, as many times as need be until a "no" answer was given. A "no" answer would lead the interviewer to reduce the amount

until a "yes" answer was given. The increment which resulted in the highest "yes" answer was recorded as the amount the respondent was willing to pay. One important advantage of the bidding game procedure is that it asks yes-no questions rather than for a dollar estimate. This is expected to yield less biased estimates of willingness to pay [Randall, 1974].

It should be noted that the respondents were instructed to assume that the method of payment used was the only possible way to finance water quality improvement. This stipulation was designed to minimize the incidence of zero bids as protests against the particular method of payment. If a respondent said that he was not willing to pay anything, he was asked a series of questions to find out why. Table 4 shows that 13.9 percent of the respondents refused to answer the sales tax questions stating that taxes are already too high or the belief that it is unfair to expect people who are adversely affected by the pollution of others to pay the costs. A respondent reporting that he did not consider his household harmed by water pollution and saw no reason to pay for improved water quality was recorded as bidding zero. Only 1.9 percent of respondents fell into this category with respect to zero payment for current recreation use value, however, 26.7 percent gave zero option value.

The hypothetical situations presented to respondents were designed to be as realistic and credible as possible. The bidding procedure was introduced with the following statement:

> "Suppose a sales tax was collected from the citizens of the South Platte River Basin for the purpose of financing water quality in this basin. All of the additional tax would be used for water quality improvements to enhance recreational enjoyment. Every Basin resident would pay the tax. All bodies of water in the River Basin would be cleaned up by 1983. Assume that this is the only way to finance water quality improvement."

The definition of recreation enjoyment was left to each individual respondent. This approach was adopted so that respondents would be more likely to estimate the total recreation value. Any particular definition of water-based recreation activities provided by the interviewer might have omitted an activity for which the respondent would be willing to pay. The estimated value of water quality to enhance the water-based recreation experience then would be biased downward. As a result, respondents conceived of water-based recreation broadly to include swimming, boating, fishing, sightseeing, picnicking, camping, hiking, driving, and other leisure time activities within view of lakes and streams.

The year 1983 was specified because it is a national goal that waterways become suitable for fish life and human contact recreation by that year. Abatement methods incorporating the best available technology which is economically achievable are to be employed by industry point source polluters by 1983.

Table 4. Total Number of Respondents Interviewed Compared to the Number Answering Questions Relating to Value of Water Quality and the Number Willing to Pay, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976.

Response	Denver Metropolitan Area		Fort Collins		South Platte River Basin	
	Number	Percent	Number	Percent	Number	Percent
Total Number Interviewed	101	100.0	101	100.0	202	100.0
Number Answering Value of Water Quality Questions						
Recreation Use Value						
Annual Sales Tax	85	84.2	89	88.1	174	86.1
Water Bill	82	81.2	78	77.2	160	79.2
Option Value						
Annual Sales Tax	88	87.1	89	88.1	177	87.6
Water Bill	83	82.2	78	77.2	161	79.7
Number Willing to Pay Some Amount						
Recreation Use Value						
Annual Sales Tax	84	83.2	86	85.1	170	84.2
Water Bill	81	80.2	75	74.3	156	77.2
Option Value						
Annual Sales Tax	65	64.3	58	57.4	123	60.9
Water Bill	59	58.4	52	51.5	111	55.0

The hypothetical situation presented to respondents regarding option value was designed to be as realistic as possible. A rereading or explanation was provided by interviewers where deemed necessary. The introductory paragraph explains a realistic coal and metal mining threat to water quality in the River Basin and possible irreversible consequences. The possibility of substituting other recreation areas is minimized. The alternative uses of water are explained, i.e., irreversibly polluted water or preservation of water quality. The option value questions were the following statements:

> "In the near future, one of two alternatives is likely to occur in the South Platte River Basin. The first alternative is that a large expansion in mining development will soon take place, creating jobs and income for the region. As a consequence, however, many lakes and streams would become severely polluted. It is highly unlikely, as is shown in Situation C, that these waterways could ever be returned to their natural conditions. They could not be used for recreation. Growing demand could cause all other waterways in the area to be crowded with other recreationists.
>
> "The second possible alternative is to postpone any decision to expand mining activities which would irreversibly pollute these waterways. During this time, they would be preserved at level A for your recreational use. Furthermore, information would become available enabling you to make a decision with near certainty in the future, as to whether it is more beneficial to you to preserve the waterways at level A for your recreational use or to permit mining development. Of course, if the first alternative takes place, you could not make this future choice since the waterways would be irreversibly polluted.
>
> "Given your chance of future recreation use, would you be willing to add _____ cents on the dollar to present sales taxes every year to postpone mining development. This postponement would permit information to become available enabling you to make a decision with near certainty in the future as to which option (recreational use or mining development) would be most beneficial to you? Would it be reasonable to add _____ to your water bill every month for this postponement?"

The bidding procedure for existence and bequest values was introduced with a question concerning the chances of future recreation use of water in the River Basin. This was designed to facilitate use of a sub-sample of non-user values. The hypothetical situation presented to respondents also was prefaced with the condition that it is certain the respondent will not use the River Basin for water-based recreation activities. The existence and bequest questions were:

"(1) What would you estimate are the chances in 100 that you will travel to lakes and streams in the South Platte River Basin in the next year, for water-based recreation if they are preserved at level A? Do you anticipate any significant change in your chances for future years? (If 'yes') What change?

"(2) If it were certain you would not use the South Platte River Basin for water-based recreation, would you be willing to add _____ cents on the dollar to present sales taxes every year, just to know clean water exists at level A as a natural habitat for plants, fish, wildlife, etc.? Would it be reasonable to add _____ to your water bill every month for this knowledge?

"(3) If it were certain you would not use the South Platte River Basin for water-based recreation, would you be willing to add _____ cents on the dollar to present sales taxes every year to ensure that future generations will be able to enjoy clean water at level A? Would it be reasonable to add _____ to your water bill every month for this knowledge?"

SECTION 4

RECREATION USE AND NON-USE VALUES

This section presents a summary and analysis of the results of the interview survey described earlier. Responses to recreation use and option value questions are first discussed and existence and bequest value estimates are described. We then aggregate the survey results to the basin population and express the estimates in terms of the present worth of a future time stream of values.

OPTION AND RECREATION USE VALUES

Option value constitutes a substantial part of the total value of improved water quality for recreation use in the South Platte River Basin. From our random sample, 175 resident households reported they were willing to pay for the option to choose to engage in water-based recreation activities in the future. Their responses averaged $22.60 per year. The preservation of water quality provides the option to make a future decision between two alternative uses of waterways in the River Basin, either for water-based recreation or for wastewater discharge by industrial and energy development, under conditions of certain knowledge about which will be more beneficial. Option value added about 40 percent to the recreation user value from enhanced enjoyment of recreation activities with improved water quality by 1983.

These same 175 resident households reported they were willing to pay an average of $56.68 annually to improve water quality in the River Basin for recreation use. This was the average value for the 80.8 percent of the households interviewed who expect to continue to use lakes and streams in the River Basin for fishing, boating, swimming, and non-contact recreation activities such as picnicking and sightseeing near water with enhanced aesthetic satisfaction of such recreation experiences. These residents' households reported an average of about slightly over 15 water-based recreation activity days annually in the River Basin, so the recreation use value of improved water quality was equivalent to $3.76 per activitiy day. The two values, current recreation use and the option value to choose future recreation use, are additive. Table 5 shows that the total recreation value of improved water quality averaged $79.28 annually, which was equivalent to $5.29 per household activity day.

There is very little empirical literature available with which to compare these results. The recreation use value of water quality improve-

Table 5. Willingness of Recreation User Households to Pay Additional Sales Tax to Improve Water Quality, Denver, Fort Collins and South Platte River Basin, Colorado, 1976.

Water Quality Values	Denver Metropolitan Area			Fort Collins			South Platte River Basin [b]		
	Tax [a] Rate Cents	Annual Dollars	Per User Day	Tax Rate Cents	Annual Dollars	Per User Day	Tax Rate Cents	Annual Dollars	Per User Day
Mean Recreation Use Value	1.00	$50.18	$3.92	1.63	$74.00	$3.57	1.17	$56.68	$3.76
95% Confidence Interval [c]		($42.94-$57.43)			($51.07-$96.94)				
Number Reporting	( )	(85)			(89)			(174)	
Mean Option Value	.39	$18.31	$1.43	.85	$34.05	$1.65	.52	$22.60	$1.50
95% Confidence Interval		($13.27-$23.36)			($20.11-$47.99)				
Number Reporting	( )	(88)			(89)			(177)	
Total Use Value	1.39	$68.49	$5.35	2.48	$108.05	$5.22	1.69	$79.28	$5.26

[a] Each one-hundredth cent increase in sales tax added 50.32 cents to annual sales tax payment, at mean income of $13,500 and a family of 4 persons. (IRS 1975 Sales Tax Table for Colorado.) These average values include those who bid zero because they felt no water quality improvement was necessary. It excludes those who refused to bid because taxes were considered already too high or for some other reason.

[b] Weighted by population. The Denver Metropolitan Area population of 1,267,000 persons excluding Boulder County was 72.7 percent of the 1,742,900 persons in the South Platte River Basin in 1976.

[c] The confidence intervals show the range of values that would include 95 percent of the means of all samples of this size drawn from the population.

ment to residents of the River Basin was similar to tourists in Rocky Mountain National Park. A substantial portion of the national park is located within the South Platte River Basin. In the Summer of 1973, park visitors reported they were willing to pay an average of $5.55 per household day to avoid water pollution where they engage in outdoor recreation activities [Ericson, 1977]. Water quality is higher in the park than in the River Basin as a whole. The park is one of the unique natural areas of the nation, with pristine rivers and lakes, and majestic mountain peaks. This unique natural setting may have influenced value estimates of these respondents.

The present estimate of the recreation use value of water quality in the South Platte River Basin was somewhat higher than a recent study of the Merrimack River Basin in New Hampshire and Massachusetts. Ostar [1977] interviewed 200 residents of that basin and found an average willingness to pay for pollution abatement of $12 per person annually. If family size averaged four persons, this would be equivalent to a value of $48 per household in that basin. This figure, however, is well within the 95 percent confidence interval of the South Platte River Basin.

The recreation use value of water quality to residents of the South Platte River Basin was similar to a national estimate. The annual use value of water quality to fishermen, boaters and swimmers was $69.59 per U.S. household in 1970 [Walsh, 1977]. This was based on a calculation of travel cost savings resulting from improved water quality, excluding travel time costs. River Basin residents have experienced less water pollution than in the industrial centers of the nation. Also, Colorado residents may have more close substitutes available, i.e., pristine high mountain rivers and lakes elsewhere in the Rocky Mountains. Davis found the bidding game approach to valuing outdoor recreation resources yields results not significantly different from the travel cost approach [Knetsch and Davis, 1966]. In any case, the fact that the national estimates prepared by the travel cost figure method falls in the 95 percent confidence interval of our South Platte survey suggests the reasonableness of the results.

The recreation use value of water quality is similar in amount to the recreation value of air quality. A 1972 survey of resident and tourist households showed a willingness to pay $85 annually to avoid aesthetic damages from air pollution by the Four Corners Power Plant at Fruitland, New Mexico [Randall, 1974]. The reliability of this study has been tested by replication under similar conditions. A random sample of households were interviewed while visiting Lake Powell in Glen Canyon National Recreation Area [Brookshire, Schulze and Ives, 1976]. In 1973, households were willing to pay an average of $2.77 per recreation day to avoid air pollution damage from the Navajo power plant visible south of the lake. It was reported that an unpublished replication of these studies in Farmington, New Mexico, also was consistent with the earlier results [Randall, 1977].

EXISTENCE AND BEQUEST VALUES

Non-user values from preservation of water quality in the South Platte River Basin were defined to include both the value placed on existence of a natural ecosystem and the value of its bequest to future generations. Table 6 compares existence and bequest values for resident user and non-user households.

From our random sample, 181 resident user households reported an average existence value of $33.86 and a bequest value of $33.01, for a total preservation value of $66.87 annually. This was the value reported by the 80.8 percent of the households interviewed who expected to continue to use lakes and streams in the River Basin for fishing, boating, swimming, and non-contact recreation activities such as picnicking and sightseeing near waterways. If there were no recreation activities in the South Platte River Basin, this group of households would still value improved water quality. Estimates of preservation values by recreation users were premised on the assumption that the respondents knew with certainty they would not engage in water-based recreation activities in the River Basin. Thus, existence and bequest value estimates by recreation users can not be added to their recreation use and option value estimates but are in lieu of them. Preservation values reported by recreation users are the expected levels if no recreation use values were present.

Non-user households reported an average existence value of $24.98 and a bequest value of $16.97, for a total preservation value of $41.95 annually. This was the value reported by the 19.2 percent of respondents who reported a zero chance of future use of the River Basin for recreation activities. The two tailed t-test of significance revealed that the value estimates for this small sub-sample of 24 respondents was significantly different from zero in the case of existence and bequest values in Denver but not in Fort Collins. A one tail test may be more appropriate for data such as this where only positive values were reported. Existence value in Fort Collins was significant in a one tail test at the 95 percent confidence level, and bequest value was significant at the 90 percent level. However, we consider the average values reasonable and a larger sub-sample would increase their significance. These estimates of non-user preservation values in the South Platte River Basin are small compared to those estimated in the Fraser River Basin, British Columbia, Canada [Meyer, 1975]. There, preservation values increase salmon fishing values by 54 percent or $233 per household annually. It should be noted that these values were reported for the preservation of a free flowing river system from a large water impoundment project, and are not strictly comparable to values from the preservation of water quality alone.

As a first approximation, the existence and bequest value estimates for the 19.2 percent of respondents who reported a zero chance of future recreation use of the River Basin are extrapolated to all residents. The procedure involves the premise that recreation users would be willing

Table 6 . Willingness of Recreation User and Non-User Households to Pay Additional Sales Tax to Improve Water Quality for Preservation of the Existence of a Natural Ecosystem and its Bequest to Future Generations, Denver, Fort Collins and South Platte River Basin, Colorado, 1976.

Water Quality Values	Denver Metropolitan Area		Fort Collins		South Platte River Basin	
	Tax Rate Cents	Annual Dollars	Tax Rate Cents	Annual Dollars	Tax Rate Cents	Annual Dollars
Resident User If Non-Use for Recreation Assumed Certain						
Existence of Natural Ecosystem	.61	$28.95	1.09	$46.92	.74	$33.86
95% Confidence Interval[a/]		($22.67-$35.22)		($32.00-$61.84)		
Number Reporting ( )		(88)		(91)		(179)
Bequest to Future Generations	.56	$28.48	1.10	$45.09	.70	$33.01
95% Confidence Interval		($22.70-$34.26)		($30.18-$60.01)		
Number Reporting ( )		(88)		(93)		(181)
TOTAL	1.17	$57.43	2.19	$92.01	1.44	$66.87
Resident Non-User Sub-sample Reporting a Zero Chance of Future Use						
Existence of Natural Ecosystem	.70	$26.03	.50	$22.17	.64	$24.98
95% Confidence Interval		($1.78-$50.29)		(-$5.33-$49.66)		
Number Reporting ( )		(15)		(9)		(24)
Bequest to Future Generations	.42	$16.43	.40	$18.42	.41	$16.97
95% Confidence Interval		($6.67-$26.19)		(-$9.70-$46.53)		
Number Reporting ( )		(15)		(9)		(24)
TOTAL	1.12	$42.46	.90	$40.59	1.06	$41.95

[a/] The confidence intervals show the range of values that would include 95 percent of the means of all samples of this size drawn from the population.

to pay as much in additional sales tax for existence and bequest values as non-users. Users were also asked existence and bequest value questions, but the resulting value estimates were much larger than those for non-users and were not considered additive to recreation users values. It was felt that many recreation users would have lowered their reported existence and bequest values if they were to be added to previously reported recreation use and option values. Therefore, the extrapolation of the smaller existence and bequest values of non-users is appealing. However appealing this procedure may be, our survey did not ask users for their existence and bequest values in such a way as to permit adding them to user's values. Thus, the extrapolation of non-user existence and bequest values over all residents cannot be interpreted as an estimate of true willingness to pay for these preservation values. It would be interesting to extend this research to allow measurement of existence and bequest values to recreation users as well as non-users in such a way as to allow them to be added to user values.

ANNUAL BENEFITS AND PRESENT VALUE OF FUTURE BENEFITS

Estimates of total annual benefits from improved water quality were prepared for the South Platte River Basin. These were used to calculate the present value of a future stream of annual benefits. Table 7 shows the annual and present values of benefits from recreation use, option, existence, and bequest demands.

Total annual benefits from water quality improvement in the South Platte River Basin were estimated at $61.1 million, inlcuding recreation use value of $26.4 million, option value of $10.5 million, existence value estimated at $14.4 million, and bequest value of $9.8 million. These annual benefits were estimated in two steps: (1) for the 80.8 percent of the households who expect to be recreation users in the future, and (2) for the 19.2 percent of households who expect to be non-users in the future. It was estimated there were 576,435 households in the River Basin in 1976. The annual benefit estimates were a weighted average based on the proportion of Basin population in the Denver Metropolitan Area and the proportion of the population in non-metropolitan areas. It was assumed that Fort Collins was representative of the non-metropolitan areas of the River Basin.

The weighted average benefits to the 80.8 percent of the households who reported they intend to engage in recreation use of the waterways in the River Basin was estimated as $121.23 annually. This is the sum of the average recreation use value of $56.68, option value of $22.60, existence value of $24.98, and bequest value of $16.97. Existence and bequest values are those reported by a sub-sample of residents who currently do not expect to use the River Basin for recreation, on the assumption that they are representative of existence and bequest values for the general population in the River Basin. This may be a conservative estimate as the experience and appreciation gained in the recreation use of these resources may result in somewhat higher estimates of existence and bequest values than for the non-user sample of the population.

Table 7 . Annual Value and Present Value of Benefits from Water Quality Improvement for Recreation, Option, Existence, and Bequest Demands by Residents of the South Platte River Basin, 1976.

Water Quality Values (Willingness to Pay Sales Tax)	Denver Metropolitan Area		Non-Metropolitan Areas		South Platte River Basin	
	Annual Value	Present Value[a]	Annual Value	Present Value[a]	Annual Value	Present Value[a]
Recreation Use Value Improvement from Polluted Water to Intermediate Level of Water Quality (C-B) by 1983	$12,491,660	$195,947,600	$750,883	$11,778,555	$18,499,947	$290,195,255
Improvement from Polluted Water to Highest Level of Water Quality (C-A) by 1983	16,886,624	264,888,216	1,191,622	18,692,110	26,399,220	414,105,414
Improved Water Quality Delayed to the Year 2000	14,594,916	228,939,855	863,765	13,549,254	21,504,093	337,319,106
Option Value	6,161,700	96,654,102	548,307	8,600,896	10,526,153	165,116,132
Existence of Natural Ecosystem	11,060,147	173,492,502	419,523	6,580,752	14,399,346	225,872,099
Bequest to Future Generations	6,981,107	109,507,561	348,562	5,467,634	9,782,102	153,444,736
Total Benefits of Highest Level of Water Quality Improvement, (C-A) by 1983 for Recreation, Option, Existence and Bequest Values	41,089,578	644,542,400	2,508,014	39,341,396	61,106,821	958,538,360

[a] Assuming a perpetual benefit stream, where Present Value = B/i, B = Annual Aggregate Benefits and i = Federal Rate of Discount, 6 3/8 percent.

The weighted average benefits to the 19.2 percent of the households who reported they do not expect to make recreational use of the waterways in the River Basin was estimated as $41.95 annually. The non-user benefits from improved water quality were the sum of existence and bequest demand values for the relevant population of non-users. Recreation use and option value estimates were excluded from non-user benefits since they reported a zero probability of future recreation use in the River Basin. These non-user households represented 14.9 percent of the Fort Collins population, and 20.8 percent of the Denver population.

The present value of a perpetual stream of benefits from water quality improvement in the South Platte River Basin was calculated as $958.5 million, including recreation use value of $414.1 million, option value of $165.1 million, existence value estimated at $225.4 million, and bequest value of $153.4 million. Present value is the amount of money that would have to be invested at interest today in order to yield the specified annual benefits from improved water quality for an indefinite period of time. The formula is PV = B/i where PV is the present value of a perpetual stream of annual benefits, B is the annual benefits from water quality improvement and i is the Federal discount rate of 6 3/8 percent currently used in calculation of benefits and costs of public projects.

The calculation of present value of future benefits is included for illustrative purposes, and is likely to be a low estimation for a number of reasons. Future benefits are assumed to remain constant at 1976 levels, which seems unlikely to occur. For one thing, population is espected to continue to grow rapidly in some parts of the River Basin, as migration from other parts of the nation continues to occur. Also, the results of the socio-economic regression analysis suggest that variables such as future growth in income, increased education levels, and changes in the age characteristics of the population will significantly increase willingness to pay for improved water quality. Substitute recreation areas may become crowded and polluted, and with more leisure time available the proportion of the population who engage in water-based recreation activities in the River Basin may increase. These trends suggest that the present value of the benefit stream may prove conservative. In addition, tourists account for approximately 30-40 percent of the total water-based recreation activities in the River Basin, and benefits to them were not estimated in this study. The value of improved water quality to non-resident tourists should be added to the resident values shown here to arrive at a complete estimate of water quality benefits in the River Basin [Ericson, 1977].

METHOD OF PAYMENT

Survey respondents indicated a greater willingness to pay for improved water when the method of hypothetical payment was an increase in sales tax rather than an increase in water bill. Comparing table 8 with tables 5 and 6 shows that willingness to pay additional water bill for improved water quality was about one-third as much as willingness to pay additional sales

Table 8. Willingness of Resident Households to Pay Additional Water Bill to Improve Water Quality, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976.

Water Quality Values	Denver Metropolitan Area		Fort Collins		South Platte River Basin	
	Monthly Water Surcharge	Annual Dollars	Monthly Water Surcharge	Annual Dollars	Monthly Water Surcharge	Annual Dollars
Recreation Use Value	$1.32	$15.84	$2.16	$25.92	$1.55	$18.60
95% Confidence Interval		($12.99-$18.69)		($11.79-$40.06)		
Number Reporting ( )		(82)		(78)		(160)
Option Value	.50	6.04	1.00	12.00	.64	7.65
95% Confidence Interval		($4.58-$7.51)		($5.86-$18.14)		
Number Reporting ( )		(83)		(73)		(160)
Existence of Natural Ecosystem[a/]	.54	6.43	.58	7.00	.55	6.60
95% Confidence Interval		($4.78-$8.07)		($5.37-$8.63)		
Number Reporting ( )		(14)		(9)		(23)
Bequest to Future Generations[a/]	.46	5.57	.42	5.00	.45	5.40
95% Confidence Interval		($3.93-$7.22)		($2.70-$7.31)		
Number Reporting ( )		(14)		(9)		(23)

[a/] Existence and bequest values shown here are for a 20 percent sub-sample of respondents who reported a zero chance of future use of the South Platte River Basin for water-based recreation activities.

tax. This was an unexpected result, as previous research suggested alternative methods of payment would not affect willingness to pay. In a controlled test of the bidding game approach to estimation of willingness to pay, Bohm [1972] found that several hypothetical methods of payment did not significantly affect results as compared to when actual payment was made.

The relative size of the estimated values for the two methods of payment was nearly identical in both Denver and Fort Collins. For example, willingness to pay additional water bill for recreation use was reported as 32 percent as much as sales tax in Denver, and 35 percent as much in Fort Collins. This suggests that factors influencing the choice of payment were general in nature. A sales tax is collected from everyone who purchases goods and services in the taxing district, including tourists, whereas water bills are paid by property owners, and only indirectly by renters. This is the free rider problem in which tourists tend to escape payment when water quality is improved primarily through water sewer district revenues [Walsh, Soper and Prato, 1977]. Respondents were more reluctant to participate in the water bill value estimation procedure. This may have resulted from perceived inequities. In portions of both cities which were not metered, small families were required to pay the same flat fee as large families. Also, with average water bill of $10-15 per month, an incremental willingness to pay of 50 cents per month is a larger percentage of the total water bill than ¼ cent in additional sales tax. Although the average willingness to pay additional sales tax for improved water quality amounted to more total annual dollars, it was approximately the same percentage of the annual sales tax bill as the water bill estimates were of the annual water bill.

RIVER BASIN VERSUS STATE VALUES OF IMPROVED WATER QUALITY

Results of this study suggest that the River Basin is an appropriate geographic area when evaluating recreation satisfaction from improved water quality. Residents of the River Basin were asked how much their willingness to pay for improved water quality would change if waterways of the entire state were improved to level A. Table 9 shows that the average willingness to pay to improve water quality throughout Colorado was slight by comparison to the river basin where residents live. The paired T-test showed no significant difference at the 5 percent level. In other words, it seems likely that residents of the River Basin are not willing to pay for improved water quality in other river basins in the state. However, residents of other river basins throughout Colorado may be willing to pay to improve water quality in their own local area. The clear implication is that these findings for the South Platte River Basin are additive to water quality values which could be estimated for each major river basin in the state.

Residents of the South Platte River Basin tend to engage in water-based recreation activity within the Basin. Denver residents reported an average of 20 water-based recreation activity days annually of which 12 or

Table 9 . Willingness of South Platte River Basin Residents to Pay an Additional Sales Tax to Improve Waterways Throughout Colorado, 1976.

Water Quality Values	Denver Metropolitan Area			Fort Collins			South Platte River Basin		
	Tax Rate Cents	Annual Dollars	Percent of Annual Bid	Tax Rate Cents	Annual Dollars	Percent of Annual Bid	Tax Rate Cents	Annual Dollars	Percent of Annual Bid
Recreation Use Value of Improved Water Quality in the South Platte River Basin	1.00	$50.18	100.0	1.63	$74.00	100.0	1.17	$56.68	100.0
95% Confidence Interval	($42.94-$57.42)			($51.07-$96.93)					
Number Reporting ( )	(85)			(89)			(174)		
Recreation Use Value of Improved Water Quality Throughout Colorado	.99	$48.88	97.4	1.70	$76.10	102.8	1.18	$56.32	98.9
95% Confidence Interval	($41.45-$56.31)			($52.70-$99.50)					
Number Reporting ( )	(86)			(89)			(175)		
Change in Willingness to Pay	-.01	-1.30	-2.6	.07	2.10	2.8	-.01	-.38	-1.1

some 60 p[illegible] were within the River Basin. Fort Collins residents reported an average of 26 water-based recreation activity days annually of which 21 or about 80 percent were within the River Basin. Still, with 20-40 percent of annual water-based recreation activities outside of the River Basin, it is surprising that residents were unwilling to pay for improved water quality at these other locations. This may be related, in part, to the opinions' respondents hold concerning who should pay for water quality improvement.

Nearly 40 percent of the residents of the River Basin were of the opinion that the community as a whole should bear the primary responsibility for paying the costs of water quality improvement. An additional 15 percent reported the opinion that the polluting industries should pay the costs, while 30 percent favored sharing the costs between polluting industries and the people benefiting.

DELAY TO YEAR 2000

The measures of willingness to pay for improved water quality throughout this report were based on the premise that all bodies of water in the River Basin would be cleaned up by 1983 and then maintained in a clean state indefinitely. If circumstances such as postponement of environmental quality objectives resulted in delaying the improvement of water quality in the South Platte River Basin to the year 2000, the proportion of respondents willing to pay some amount of additional sales tax for improved water quality declined from 170 to 151 or by 11 percent. If it is not possible to improve water quality in the South Platte River Basin until the year 2000, annual willingness to pay for recreation use may fall by an average of $10.51 per household or 18.5 percent. Table 10 shows the relative values for Denver and Fort Collins. As water pollution abatement is delayed, water quality values in Fort Collins fall at a rate about twice as fast as Denver. The differences in values reported in the two cities are significant at the five percent level.

Understanding the effects of a delay in the improvement of water quality on recreation values is important. It appears that the goals established for water quality will not be met by 1983 in the South Platte River Basin. The Environmental Protection Agency [1977] reports that:

> Current water quality in the South Platte River and its tributaries is generally poor. Relatively good water quality is found in streams' headwaters at the fringes of the urbanized Denver region, but water quality deteriorates as the streams flow through the urban area. By the time the South Platte reaches Henderson downstream of Denver, water quality closely resembles the treated discharge from a sewage treatment plant. The alternative strategies evaluated in the EIS all result in improved water quality by 1983, but the goals established for water quality are not met.

Table 10. Effects of Delay to the Year 2000 on Willingness to Pay an Additional Sales Tax to Improve Water Quality in the South Platte River Basin, Colorado, 1976.

Water Quality Values	Denver Metropolitan Area			Fort Collins			South Platte River Basin		
	Tax Rate Cents	Annual Dollars	Percent of Annual Bid	Tax Rate Cents	Annual Dollars	Percent of Annual Bid	Tax Rate Cents	Annual Dollars	Percent of Annual Bid
Recreation Use Value of Improved Water Quality by 1983	1.00	$50.18	100.0	1.63	$74.00	100.0	1.17	$56.68	100.0
95% Confidence Interval	($42.94-$57.42)			($51.07-$96.93)					
Number Reporting ( )	(85)			(89)			(174)		
Recreation Use Value of Improved Water Quality Delayed to the Year 2000	.89	$43.37	86.4	1.22	$53.64	72.5	.98	$46.17	82.60
95% Confidence Interval	($35.59-$51.15)			($37.73-$69.55)					
Number Reporting ( )	(86)			(89)			(175)		
Change in Willingness to Pay	-.11	-6.81	13.6	-.41	-20.36	27.5	-.19	-10.51	17.40

LEVEL OF WATER QUALITY

Table 11 shows the relationship between level of water pollution control and willingness to pay additional sales tax for improved water quality. This is the willingness to pay for enhanced recreation use, as respondents were not asked for the value of option, existence and bequest demand attached to an intermediate level of water quality. With only the three data points shown, it is perhaps heroic to generalize about the nature of the slope of the benefit curve [Greenley, 1977]. The average values suggest that recreation use benefits from water quality improvement increase at a decreasing rate, which is consistent with decreasing marginal utility of consumption observed for private consumption goods.

In Fort Collins, improving polluted water to an intermediate water quality level (from C to B on the photographs) accounted for 63 percent of total recreation use benefits from clean water. This is similar to research results concerning benefits of air quality improvement. It has been shown that improving air quality to an intermediate level accounts for 57 [Brookshire, Schulze and Ives, 1976] to 59 percent [Randall, 1974] of total aesthetic benefits from clean air.

Even more of the benefits to residents of Denver are realized by improving water quality from the worst condition of pollution to an intermediate level, from C to B. The intermediate level of water pollution control depicted accounted for 74 percent or $37.12 annually of total values reported for improving water quality from polluted to clean levels. This is consistent with recent experience in the Denver Metropolitan Area. Benefits have accrued to residents from partial improvement of water quality from year to year. In Central Denver, the quality of the South Platte River has been improved from a level which would not support fish life to a level which now can sustain lower levels of fish life such as catfish and bullheads. This may be considered an improvement from a classification of polluted to an intermediate level of water quality (from C to B), for the river does not yet contain sufficient dissolved oxygen to sustain game fish such as trout. When the highest level of improvement is eventually achieved, it may be considered an improvement from intermediate water quality to clean water (from B to A). When the South Platte River becomes clean, the additional recreation use benefits to Denver residents will increase by $13.06 annually representing 26 percent of the total value of water quality reported by Denver residents in 1976.

Since an improvement in water quality from situation C to situation B accounts for a larger reduction in pollution than from B to A, these estimates appear to be reasonable. Heavy metal pollution was used as a proxy of water pollution rather than the more general indices of dissolved oxygen and biochemical oxygen demand. Heavy metal content was selected since in many areas of Colorado it has resulted in irreversible degradation with prohibitively high cost of pollution control. Irreversible consequences from mineral and energy development was an essential assumption in the estimation of option value. Heavy metal effluent results in many of the

Table 11. Effect of Level of Water Pollution Control on Willingness of Residents to Pay an Additional Sales Tax to Improve Water Quality for Recreation Use in the South Platte River Basin, Colorado, 1976.

Water Quality Values	Denver Metropolitan Area			Fort Collins			South Platte River Basin		
	Tax Rate Cents	Annual Dollars	Percent of Annual Bid	Tax Rate Cents	Annual Dollars	Percent of Annual Bid	Tax Rate Cents	Annual Dollars	Percent of Annual Bid
Improvement from Polluted Water to an Intermediate Level of Water Quality (C to B)[a]	.73	$37.12	74.0	1.13	$46.63	63.0	.83	$39.72	70.1
95% Confidence Interval		($30.62-$43.62)			($33.45-$59.81)				
Number Reporting ( )		(86)			(89)			(175)	
Improvement from an Intermediate Level to Clean Water[a] (B to A)	.27	$13.06	26.0	.50	$27.37	37.0	.34	$16.96	29.9
Number Reporting ( )		(86)			(89)			(175)	
Total Improvement from Polluted Water to Clean Water (C to A)[a]	1.00	$50.18	100.0	1.63	$74.00	100.0	1.17	$56.68	100.0
95% Confidence Interval		($42.94-$57.42)			($51.07-$96.93)				
Number Reporting ( )		(86)			(89)			(175)	

[a] Levels A, B and C refer to water qualities associated with photographs presented on page 26 of Section 3, above.

same problems as do other effluents, such as fish kills. Some metals, such as the presence of iron which results in acid formation, have a more pronounced effect on water quality and adjacent wildlife community. However, an objective basis for weighting was unavailable. Although situations B and A are quite close together in metals content relative to situation C, there is a significant change in the level of water quality. Fish and wildlife are still limited by the toxic effects of the water in situation B while the water in situation A is pure and non-toxic. Situation B is representative of areas with approximately 1,158 micrograms of heavy metals per liter of water, situation C with approximately 181,250 micrograms of heavy metals per liter of water, and situation A where undetected trace elements remain represents clean water. Situation C depicts the worst water quality level within the South Platte River Basin where metalic content exceeds recommended drinking water standards and biological limits for fish survival. The proportion of waterways polluted to this extent was not specified. Thus respondents provided estimates of benefits based on their personal experience and judgement of the actual amount of pollution in the River Basin.

INTER-CITY COMPARISONS

The t-test showed there was no significant statistical difference between values reported in the two cities at the 95 percent level of significance. Tables 5 and 6 show the average willingness to pay additional sales tax for improved water quality in Denver and Fort Collins. Annual average values are higher in Fort Collins than Denver with the exception of the sub-sample of non-users where existence and bequest values are slightly higher in Denver. This would suggest that as size of city is increased, the recreation use value of water quality in the South Platte River Basin may tend to decrease relative to preservation value. Resident households in Fort Collins were willing to pay $108.05 annually in additional sales tax for improved water quality for recreation use compared to about $68.49 for resident households in Denver, or nearly 60 percent more. However, a non-user sub-sample of Denver residents were willing to pay an average of $42.46 annually in additional sales tax to preserve water quality for existence and bequest demands compared to $40.59 for residents of Fort Collins.

It was expected that differences between annual water quality values for recreation use would be related to differences in the number of days of recreation use of the South Platte River Basin. Denver residents reported fewer days of water-based recreation use of the River Basin than Fort Collins residents. Average household use days were reported as 12.8 in Denver compared to 20.7 in Fort Collins. When annual water quality values were divided by the number of days the River Basin was used, there was no appreciable difference between value of water quality for recreation

use in the two cities (Table 5). Average total recreation use value (including option value) was $5.35 per day in Denver and $5.22 in Fort Collins. However, the variable, days of water-based recreation use of the River Basin, was not statistically significant in explaining willingness to pay for improved water quality, as will be shown in the following section.

SECTION 5

EFFECT OF SOCIOECONOMIC VARIABLES ON WILLINGNESS TO PAY FOR IMPROVED WATER QUALITY

A total of 30 variables representing socioeconomic attributes of respondents were tested with multiple regression analysis for significance in explaining willingness to pay for improved water quality. Of these, 15 variables were found to be significant at the 5 percent level. Together they explained as much as 47 percent of the variation in willingness to pay for improved water quality, although some of the equations explained less. The results are summarized in Table 12. A discussion of the significant socioeconomic variables is included in this section, along with tables showing a simple cross tabulation of average values for the more important socioeconomic variables including: household income, sex, employment, permanence of residence, previous residence, reasons for moving, number of children, age and recreation activities.

HOUSEHOLD INCOME

Table 13 shows household income and willingness to pay additional sales tax for improved water quality. The cross tabulation of the two variables suggests that average income may be positively related to the average value of water quality. As income increases, the value of improved water quality in the South Platte River Basin also tends to increase. The trends is not always consistent. For example, households with incomes at the mean of $15,000-15,999 were willing to pay less for recreation use than households below the mean with incomes of $8,500-10,999. However, households with even lower incomes were willing to pay even less. Moreover, households with incomes of $21,000 and above (estimated average of $32,000) were willing to pay substantially more by nearly every measure. This suggests that general prosperity which resulted in increased real personal income for Colorado residents would increase the value of improved water quality in the South Platte River Basin.

Level of household income was significant at the 5 percent level in the regression analysis of variables associated with the value of improved water quality for recreation use. For example, in Fort Collins a $1,000 increase in household income was associated with a $3.66 increase in annual willingness to pay for improved water quality via a sales tax. Income levels and the willingness to pay by Denver residents may be associated with the family life cycle. As age increases, the value of water quality increases per $1,000 of added family income, but the effect is slight. Table 14 shows that as age increases by 10 years, the marginal effect of a $1,000

Table 12 . Regression Coefficients of Significant Socioeconomic Variables, Denver and Fort Collins, Colorado, 1976.

Significant Independent[a/] Variable (5 percent level)	Recreation Use Value				Option Value			
	Sales Tax		Water Bill		Sales Tax		Water Bill	
	Denver	Fort Collins	Denver	Fort Collins	Denver	Fort Collins	Denver	Fort Collins
	Regression Coefficient							
X_1 Family Income		.00366			.00068	.00153		
X_{22} 1/Family Income							15,176	
X_{26} Family Income X Age	.00001					38.04	3.65	
X_7 Sex-Male	26.55	56.45	6.92					
X_{19} Employer-Government	28.44		28.01	7.18	3.19			2.71
X_5 Education				8.44				
X_9 Previous Residence (5,000-25,000)					7.70		5.02	
X_4 Age					-.66		-.15	
X_{13} Occupation-Professional/ Business Owner-Manager	-21.67				-14.07			
X_{24} 1/Years Lived in City			.34					
X_{20} Number of Children						-10.45		
X_{11} Previous Residence (100,000+)		45.62						
X_{14} Occupation-Housewife	20.91							
X_{15} Occupation-Retired	-30.03							
X_{17} Employer-Small Business	25.08							
Fraction of Explained Variance (R^2)	.4721	.2141	.3518	.1949	.2857	.1678	.2390	.3809

[a/] See the Statistical Appendix for coding of variables.

Table 13. Household Income and Willingness to Pay Additional Sales Tax for Improved (C-A) Water Quality, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976.

Water Quality Values	Household Income Groups								
	Under 6,000	6,000-8,499	8,500-10,999	11,000-13,499	13,500-15,999	16,000-18,499	18,500-20,999	21,000[a] or more	Total or Average
	Willingness to Pay Additional Sales Tax (Dollars per Year)								
Recreation Use Value									
Denver Metro Area	$22.77	$51.96	$51.08	$42.94	$42.85	$50.17	$46.33	$70.25	$50.18
Number Reporting ( )	(11)	(7)	(9)	(8)	(12)	(6)	(9)	(23)	(85)
Fort Collins	31.87	46.43	84.88	36.03	78.58	48.05	147.42	133.52	74.00
Number Reporting ( )	(13)	(10)	(10)	(16)	(13)	(5)	(6)	(16)	(89)
South Platte River Basin	25.29	50.43	60.44	41.02	52.75	49.58	73.93	87.78	56.68
Option Value									
Denver Metro Area	9.35	7.03	18.36	29.17	17.67	11.46	13.53	26.74	18.31
Number Reporting ( )	(12)	(8)	(9)	(8)	(12)	(6)	(9)	(24)	(88)
Fort Collins	28.50	32.80	52.80	15.20	16.58	10.00	46.50	63.52	34.05
Number Reporting ( )	(13)	(10)	(10)	(16)	(13)	(5)	(6)	(16)	(89)
South Platte River Basin	14.65	14.16	27.90	25.30	17.37	11.06	22.53	36.93	22.60
Total Value									
Denver Metro Area	32.13	58.99	69.44	72.11	60.52	61.63	59.86	96.99	68.49
Fort Collins	60.37	79.23	137.68	51.23	95.16	58.05	193.92	197.04	108.05
South Platte River Basin	39.94	64.59	88.34	66.32	70.12	60.64	96.46	124.71	79.28

[a] An average of $32,000.

Table 14 . Marginal Effect of a Change of Income on Willingness to Pay Additional Sales Tax for Improved Water Quality, at Various Age Levels, Denver Metropolitan Area, Colorado, 1976.

Age of Respondent	Change in Willingness to Pay Added Sales Tax per Year per $1,000 Of Added Family Income[a/]
20	$0.20
30	.30
40	.40
50	.50
60	.60
70	.70

[a/] Since the variable defined as the cross-products of age and income were significant, the marginal effect of income on willingness to pay increased sales tax for improved water quality was computed by taking the derivative of the regression equation and substituting various ages. This gives

$$\frac{\partial Y_6}{\partial x_1} = B_{26}x_4$$

where the variables are defined as in Table and B_{26} is the regression coefficient of the cross-products. Substituting the regression coefficient and various ages into the above equation will yield the marginal effect of income on willingness to pay.

increase in income is to increase the value of water quality by an additional 10 cents per household. In this calculation the variation across individuals in the effects on willingness to pay of all variables shown in the statistical appendix are adjusted for by multiple regression.

Regression analysis showed a significant relationship between household income and option value of water quality, as measured by willingness to pay additional sales tax. The relationship was a positive one in both the Denver Metropolitan Area and Fort Collins. There was a negative correlation between household income and option value of water quality in Fort Collins, as measured by willingness to pay additional water bill. This is inconsistent with the findings regarding willingness to pay a sales tax for improvement in water quality. One possible explanation for the negative association may be a tendency for those with higher income levels in Fort Collins to have a vested interest in the pollution of water resources from economic development. They would be willing to pay little to postpone economic development merely for the option to choose a recreation use of the South Platte River Basin. They are quite sure now they will not choose water quality over pollution from development in the future. A higher proportion of Fort Collins residents engage in water-based recreation activities outside of the River Basin than do Denver residents. Higher income households are more able to travel long distances to fish in Wyoming, northwestern Colorado and other places where recreation water resources tend to be less polluted.

SEX OF RESPONDENT

Table 15 shows the sex of respondents and average willingness to pay additional sales tax for improved water quality. It can be seen from the cross tabulation that, on the average, men were willing to pay more for water quality than women. In regression analysis of socioeconomic variables associated with the value of improved water quality for recreation use, sex of the respondent had a significant effect. Sexual differences were significant in both cities, but the effect was greater in Fort Collins. There, the value of improved water quality for recreation use to male respondents was more than double (2.4 times) the value reported by female respondents. In Denver, male responses were nearly 60 percent greater than those of females.

The primary reason may be that men tend to engage in water-based recreation activities more than women, particularly fishing and to some extent boating. Both men and women swim in nearly equal proportions and more women than men go sightseeing, picnicking, and walking for pleasure, much of which occurs along lakes and streams [Adams, Lewis and Drake, 1973].

More men than women work outside the home and thus observe the condition of water quality in the streams and lakes which they pass on the way to and from work. This may result in a greater awareness of water quality among male respondents. Supporting this hypothesis, it can be seen in the table that retired persons who do not leave the home on a regular basis as employed persons have lower water quality values. Contrary to this hypothesis, however, housewives who do not work outside the home place a higher value on water quality. Most likely women who work outside the home account for the lower value of water quality attributed to women respondents

Table 15. Sex of Respondent and Willingness to Pay Additional Sales Tax for Improved (C-A) Water Quality, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976.

Water Quality Values	Sex		Total or Average
	Female	Male	
	Willingness to Pay Sales Tax (Dollars per Year)		
Recreation Use Value			
Denver Metro Area	$42.81	$59.30	$50.18
Number Reporting ( )	(47)	(38)	(85)
Fort Collins	40.52	93.73	74.00
Number Reporting ( )	(33)	(56)	(89)
South Platte River Basin	42.18	68.10	56.68
Option Value			
Denver Metro Area	19.14	17.37	18.31
Number Reporting ( )	(47)	(41)	(88)
Fort Collins	11.02	47.63	34.05
Number Reporting ( )	(33)	(56)	(89)
South Platte River Basin	16.89	25.63	22.60
Total Value			
Denver Metro Area	61.95	76.67	68.49
Fort Collins	51.54	141.36	108.05
South Platte River Basin	59.07	94.33	79.28

as a group. Perhaps households in which women work outside the home tend to be on an especially tight budget, either because no male adult is present or two bread-winners are necessary to make ends meet.

EMPLOYMENT

Both where people work and the type of work they do have a significant effect on the value of improved water quality for recreation use. Table 16 shows where people work and willingness to pay additional sales tax for improved water quality. The average values suggest that employees of government and small business are willing to pay more for water quality than either employees of large business and manufacturing or unemployed persons in Denver. However, in Fort Collins employees of large business and manufacturing are willing to pay more for improved water quality than small business and agriculture employees. Average skill levels of business employees may be higher in Fort Collins, which has several high technology firms in close proximity.

Government employees were willing to pay more for improved water quality in 4 of the 6 regression equations. Government employees in Denver were willing to pay $3.91 more for option value and $28.44 more for water quality improvement for enhanced recreational opportunities than employees of the private sector. Denver is a center of national and regional government. Government employees may have a greater awareness of environmental problems in the region. In many cases these employees work in areas of environment concern and planning. The Denver Federal Center includes employees of the Bureau of Reclamation, Bureau of Land Management, the U.S. Forest Service, the U.S. Geological Survey, Environmental Protection Agency and other environmental research branches. The Colorado Water Quality Control Commission, the Denver Water Board, the Division of Wildlife and state and local planning agencies are also located in Denver.

Table 17 shows the type of work people do and average willingness to pay additional sales tax for improved water quality. The average values suggest that, in Denver, housewives are willing to pay more than professionals, business owners and managers, those in other occupations, and the retired. In Fort Collins, however, professionals, business owners and managers are willing to pay more than those in other occupations, and housewives reported the lowest values, even lower than retired persons.

The type of work people do was significant in regression analysis of variables associated with the value of improved water quality for recreation use, as measured by willingness to pay additional sales tax. In the Denver Metropolitan Area, regression results show that professionals and business owners and managers value water quality by $21.67 less than other occupations. Retired residents value water quality by $30.03 less than those who remain active in the work force. Housewives were willing to pay $20.91 more than those employed in other occupations. Since this

Table 16. Where People Work and Willingness to Pay Additional Sales Tax for Improved (C-A) Water Quality, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976.

Water Quality Values	Employer				
	Small Business and Agriculture	Large Business and Manufacturing	Government	Other[a] and Unemployed	Total or Average
	Willingness to Pay Additional Sales Tax (Dollars per Year)				
Recreation Use Value					
Denver Metro Area	$60.02	$44.12	$66.23	$43.74	$50.18
Number Reporting ( )	(14)	(13)	(14)	(44)	(85)
Fort Collins	57.96	112.25	103.00	44.53	74.00
Number Reporting ( )	(23)	(10)	(28)	(28)	(89)
South Platte River Basin	59.45	62.72	76.42	43.96	56.68
Option Value					
Denver Metro Area	11.46	13.73	23.24	20.95	18.31
Number Reporting ( )	(16)	(13)	(15)	(44)	(88)
Fort Collins	23.04	60.95	44.63	22.90	34.05
Number Reporting ( )	(23)	(10)	(28)	(28)	(89)
South Platte River Basin	14.76	26.62	29.17	21.49	22.60
Total Values					
Denver Metro Area	71.48	57.85	89.47	64.69	68.49
Fort Collins	81.00	173.20	147.63	67.43	108.05
South Platte River Basin	74.12	89.34	105.59	63.45	79.28

[a] Other include petro-chemicals and mining.

Table 17. Occupation and Willingness to Pay Additional Sales Tax for Improved (C-A) Water Quality, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976.

Water Quality Values	Occupation				
	Professionals, Business Owners, and Managers	Housewife	Retired	Other[a/]	Total or Average
	Willingness to Pay Sales Tax (Dollars per Year)				
Recreation Use Value					
Denver Metro Area	$52.44	$58.63	$29.07	$53.41	$50.18
Number Reporting ( )	(23)	(17)	(14)	(31)	(85)
Fort Collins	94.00	38.61	41.68	76.50	74.00
Number Reporting ( )	(33)	(11)	(11)	(32)	(89)
South Platte River Basin	63.95	53.08	32.65	59.71	56.68
Option Value					
Denver Metro Area	16.66	30.11	6.97	18.98	18.31
Number Reporting ( )	(24)	(17)	(16)	(31)	(88)
Fort Collins	39.64	7.93	6.27	46.06	34.05
Number Reporting ( )	(33)	(11)	(11)	(34)	(89)
South Platte River Basin	23.03	23.97	6.78	26.37	22.60
Total Value					
Denver Metro Area	69.10	88.74	36.04	72.39	68.49
Fort Collins	133.64	46.54	47.95	122.56	108.05
South Platte River Basin	86.98	77.05	39.43	86.08	79.28

[a/] Other includes skilled, foreman, salesman, keeper, office worker, unskilled and student.

variable entered only one of the six regressions it is difficult to conclude that it may effect a similar general response from the Basin population.

EDUCATION

Table 18 shows years of education and average willingness to pay additional sales tax for improved water quality. The cross tabulation of the two variables shows that average education level attained is positively related to the value of water quality. As mean schooling increases, the mean value of improved water quality in the South Platte River Basin tends also to increase. While the trend is not wholly consistent and there are few in the sample with less than a high school education, it is clear that they valued water quality less than those who graduated from high school. High school graduates and college graduates valued water quality less than those with professional or graduate level education beyond the college level.

Level of education was significant at the 5 percent level in regression analysis of the factors explaining the value of improved water quality for recreation use. In Fort Collins there was a positive correlation between level of education and the value of water quality, as measured by willingness to pay a higher water bill. Each additional year of schooling was associated with a $2.71 increase in option value and a $8.44 increase in recreation use value. This suggests that educational attainment may be associated more with concern about environmental quality. No explanation is available as to why this variable was not significant in Denver.

FORMER RESIDENCE

Table 19 shows where people lived before moving to this area and average willingness to pay additional sales tax for improved water quality. The average values suggest the effects vary between the two cities. Rural immigrants to Denver value water quality more highly for recreation use than immigrants from other cities whether small or large, with the lowest values reported for immigrants from large cities of 100,000 people or more. In Fort Collins, immigrants from large cities valued water quality more highly than other immigrants. There, rural immigrants reported the lowest values.

Place of former residence was significant in regression analysis of variables associated with the recreation use and option value of improved water quality. For Denver Metropolitan Area residents, the smaller the place of former residence, the more they tended to value water quality. These former residents of rural areas and small cities may have had easier access to recreation areas hence more recreational use of lakes and streams than those from large cities. Having developed an appreciation for the

Table 18. Education and Willingness to Pay Additional Sales Tax for Improved (C-A) Water Quality, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976.

Water Quality Values	Years of Education						
	8	9-11	12	13-15	16	Over 16	Total or Average
	Willingness to Pay Additional Sales Tax (Dollars per Year)						
Recreation Use Value							
Denver Metro Area	$26.00	$45.44	$46.88	$56.95	$47.30	$48.19	$50.18
Number Reporting ( )	(1)	(4)	(17)	(28)	(23)	(12)	(85)
Fort Collins	10.42	30.80	67.16	79.68	56.70	112.01	74.00
Number Reporting ( )	(3)	(5)	(21)	(21)	(12)	(20)	(89)
South Platte River Basin	21.68	41.38	52.50	63.15	49.90	65.87	56.68
Option Value							
Denver Metro Area	8.88	7.69	13.40	27.17	19.04	9.47	18.31
Number Reporting ( )	(2)	(4)	(18)	(28)	(23)	(13)	(88)
Fort Collins	2.83	3.10	40.67	22.93	29.92	55.13	34.05
Number Reporting ( )	(3)	(5)	(21)	(21)	(19)	(20)	(89)
South Platte River Basin	7.20	6.42	20.95	26.01	22.05	22.12	22.60
Total Value							
Denver Metro Area	34.88	53.13	60.28	84.12	66.34	57.66	68.49
Fort Collins	13.25	33.90	107.83	102.61	86.82	167.14	108.05
South Platte River Basin	28.88	47.80	73.45	89.16	71.95	87.99	79.28

Table 19. Size of Place of Previous Residence and Willingness to Pay for Improved (C-A) Water Quality, Denver, Fort Collins and South Platte River Basin, Colorado, 1976.

Water Quality Values	Size of Place of Previous Residence				
	100,000+	25,000-100,000	5,000-25,0000	Rural	Total or Average
	Willingness to Pay Sales Tax (Dollars per Year)				
Recreation Use Value					
Denver Metro Area	$43.73	$52.20	$54.44	$63.96	$50.18
Number Reporting ( )	(41)	(23)	(12)	(7)	(85)
Fort Collins	107.49	55.51	85.25	31.72	74.00
Number Reporting ( )	(30)	(26)	(16)	(17)	(89)
South Platte River Basin	61.13	53.12	62.97	55.03	56.68
Option Value					
Denver Metro Area	14.97	15.62	32.64	7.00	18.31
Number Reporting ( )	(41)	(25)	(13)	(7)	(88)
Fort Collins	47.60	26.49	48.39	8.20	34.05
Number Reporting ( )	(30)	(26)	(16)	(17)	(89)
South Platte River Basin	23.87	18.63	37.00	7.33	22.60
Total Value					
Denver Metro Area	58.70	67.82	87.08	70.96	68.49
Fort Collins	155.59	82.00	133.64	39.92	108.05
South Platte River Basin	85.00	71.85	99.97	62.36	79.28

natural environment, they may place special emphasis on preserving it for recreation use in the future. For residents of Fort Collins, regression analysis shows the larger the place of former residence, the more they value water quality. Perhaps those who are willing to pay more for improved water quality tend to migrate to smaller cities which have outdoor recreation resources nearby, while those who are less willing to pay for water quality tend to remain in large cities.

REASONS FOR MOVING

Table 20 shows reasons for moving to Colorado and willingness to pay additional sales tax for improved water quality. The average values suggest that residents who immigrated to the River Basin for environmental reasons may value water quality more highly than those who came for other reasons. This is not the case for residents of the Denver Metropolitan Area, where those who moved there for family reasons value water quality most highly. Those who moved there for economic and other reasons such as quality of the public services valued water quality less. This is also the case in Fort Collins. However, Fort Collins residents who moved there for environmental reasons place the highest value on water quality. This is sufficient to overcome the lower values by those who moved to Denver for environmental reasons, so that the overall South Platte River Basin estimate of the value of water quality for recreation use is highest for those who moved there for environmental reasons. This is in accord with the widespread belief that people move to Colorado because of its reputation for a quality living environment. However, reasons for moving to Colorado were not significant in regression analysis of variables associated with the value of improved water quality for recreation use or for option value.

PERMANENCE OF RESIDENCE

Table 21 shows how long people live in one place and willingness to pay additional sales tax for improved water quality. The cross tabulation of the two variables suggests that, on average, the longer people live in one place, the less they are willing to pay for water quality improvement for recreation use. The trend is not always consistent, but newly arrived residents of less than 5 years were willing to pay over one-fourth more than long standing residents of 11-20 years. The same relationship was apparent in Fort Collins. Newly arrived residents were willing to pay more than twice as much as residents of 11-20 and 21-40 years. This suggests that immigration of people into the state in recent decades may have increased the value of improved water quality for recreation use.

Permanence of residence was a significant variable in regression analysis of variables associated with the value of improved water quality for recreation use, as measured by willingness to pay additional water bill. In the Denver Metropolitan Area, for example, additional years of residence

Table 20. Reason for Moving to Colorado and Willingness to Pay Additional Sales Tax for Improved (C-A) Water Quality, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976.

Water Quality Values	Reason for Moving to Colorado				
	Environmental	Economic or Other[a/]	Family/Native	School	Total or Average
	Willingness to Pay Additional Sales Tax (Dollars per Year)				
Recreation Use Value					
Denver Metro Area	$49.60	$49.54	$52.59	$47.00	$50.18
Number Reporting ( )	(23)	(39)	(20)	(31)	(85)
Fort Collins	110.71	61.94	65.93	64.96	74.00
Number Reporting ( )	(19)	(28)	(20)	(22)	(89)
South Platte River Basin	66.28	35.82	56.30	51.97	56.68
Option Value					
Denver Metro Area	13.76	17.65	25.71	17.08	18.31
Number Reporting ( )	(26)	(39)	(20)	(3)	(88)
Fort Collins	41.33	29.73	21.96	44.26	34.05
Number Reporting ( )	(19)	(28)	(20)	(22)	(89)
South Platte River Basin	21.28	21.00	24.67	24.61	22.60
Total Value					
Denver Metro Area	63.36	67.19	78.30	64.08	68.49
Fort Collins	152.04	91.67	87.94	109.22	108.05
South Platte River Basin	87.56	56.82	80.97	76.58	79.28

[a/] Other includes quality of public services.

Table 21. Permanence of Residence a Willingness to Pay Additional Sales Tax for Improved (C-A) Water Quality, Denver, Fo llins, and South Platte River Basin, Colorado. 1976.

Water Quality Values	Number of Years Lived in Area					
	1-5	6-10	11-20	21-40	Over 40	Total or Average
	Willingness to Pay Additional Sales Tax (Dollars per Year)					
Recreation Use Value						
Denver Metro Area	$55.58	$43.23	$44.32	$53.78	$43.83	$50.18
Number Reporting ( )	(19)	(13)	(12)	(32)	(9)	(85)
Fort Collins	108.32	70.85	46.40	41.55	22.88	74.00
Number Reporting ( )	(38)	(13)	(17)	(15)	(6)	(89)
South Platte River Basin	69.98	50.77	44.89	50.44	38.03	56.68
Option Value						
Denver Metro Area	23.33	18.51	19.61	18.31	6.70	18.31
Number Reporting	(19)	(13)	(14)	(32)	(10)	(88)
Fort Collins	53.45	36.94	16.63	13.38	5.92	34.05
Number Reporting	(38)	(13)	(17)	(15)	(6)	(89)
South Platte River Basin	31.67	23.62	18.78	16.96	6.48	22.60
Total Value						
Denver Metro Area	78.91	61.74	63.92	72.09	50.53	68.49
Fort Collins	161.77	107.79	63.03	54.93	28.80	108.05
South Platte River Basin	101.65	74.39	63.67	67.40	44.51	79.28

in the city was associated with a decrease in willing to pay additional water bill for water quality improvement. Permanence of residence was not a significant variable in regression analysis of variables associated with the option value of improved water quality. Still, the average values shown in Table suggest that newly arrived residents tend to report higher values for improved water quality than residents who have lived in the area for a longer time. This appears contrary to the usual effects of permanence of community residency. Sociologists suggest that community and area pride grow as length of residency increases. Community social bonds are stronger and neighborhoods are better preserved. Thus, it would be reasonable to expect that long term residents would value improved water quality more highly than newer residents. This enigma can be partially explained by the finding of a correlation coefficient of .55 between length of residency and age. There is a tendency for water-based recreation activity to decrease with age, hence the comparison of averages can be misleading.

AGE OF RESPONDENT

Table 22 shows the age of respondent and willingness to pay additional sales tax for improved water quality. The average values suggest that age of respondent may be negatively related to the value of water quality. As age increases, the value of improved water quality in the South Platte River Basin tends to decline. The trend is not always consistent. For example, youths of 18-29 years of age are not as willing to pay for recreation use as are the middle aged, 30-49 years. However, middle aged respondents are willing to pay more than older persons, those 50-65 years of age and those retired, over 65 years of age. This suggests that recent immigration of young adults may tend to increase the value of improved water quality in the River Basin.

Age of the respondent was not significant at the 5 percent level in regression analysis of the factors associated with value of improved water quality for recreation use. However, in the Denver Metropolitan Area, there was a significant negative correlation between age and option value of water quality, as measured by willingness to pay a higher water bill. As age increased, willingness to pay declined. For each 10 years increase in age, willingness to pay declined by $6.60 per year. This would seem reasonable as young people expect to live longer than older people and have more at stake in preserving their option to engage in water-based recreation activities in the South Platte River Basin in the future.

SIZE OF HOUSEHOLD

Table 23 shows size of household and willingness to pay additional sales tax for improved water quality. As can be seen from the cross tabulation of the two variables, the average value of water quality appears to be inversely related to size of family. As the number of children in resident household declines, the value of improved water quality in the

Table 22. Age and Willingness to Pay Additional Sales Tax for Improved (C-A) Water Quality, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976.

Water Quality Values	Age (Years)				
	18-29	30-49	50-64	Over 64	Total or Average
	Willingness to Pay Additional Sales Tax (Dollars per Year)				
Recreation Use Value					
Denver Metro Area	$46.71	$53.67	$50.35	$48.98	$50.18
Number Reporting ( )	(24)	(27)	(22)	(12)	(85)
Fort Collins	66.43	104.07	59.93	35.54	74.00
Number Reporting ( )	(31)	(31)	(14)	(13)	(89)
South Platte River Basin	50.10	67.63	53.00	45.26	56.68
Option Value					
Denver Metro Area	27.40	21.09	13.32	5.59	18.31
Number Reporting ( )	(24)	(27)	(23)	(14)	(88)
Fort Collins	43.19	44.04	18.04	5.67	34.05
Number Reporting ( )	(31)	(31)	(14)	(13)	(89)
South Platte River Basin	31.71	27.45	14.63	5.61	22.60
Total Value					
Denver Metro Area	74.11	74.76	63.67	54.57	68.49
Fort Collins	109.62	148.11	77.97	41.21	108.05
South Platte River Basin	81.81	95.08	67.63	50.87	79.28

Table 23. Size of Household and Willingness to Pay Additional Sales Tax for Improved (C-A) Water Quality, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976.

Water Quality Values	Number of Children					
	0	1	2	3	4 or more	Total or Average
	Willingness of Pay Additional Sales Tax (Dollars per Year)					
Recreation Use Values						
Denver Metro Area	$48.63	$53.65	$41.32	$62.67	$52.84	$50.18
Number Reporting ( )	(23)	(10)	(23)	(13)	(16)	(85)
Fort Collins	70.98	88.15	95.08	35.89	39.89	74.00
Number Reporting ( )	(27)	(10)	(32)	(13)	(7)	(89)
South Platte River Basin	54.73	63.21	56.21	55.25	49.25	56.68
Option Value						
Denver Metro Area	19.17	12.65	16.67	20.13	22.28	18.31
Number Reporting ( )	(23)	(10)	(24)	(14)	(17)	(88)
Fort Collins	45.00	69.55	25.99	10.12	22.39	34.05
Number Reporting ( )	(27)	(10)	(32)	(13)	(7)	(89)
South Platte River Basin	26.23	28.41	19.25	17.36	22.31	22.60
Total Value						
Denver Metro Area	67.80	66.30	57.99	82.80	75.12	68.49
Fort Collins	115.98	157.70	121.07	46.01	62.28	108.05
South Platte River Basin	80.96	91.62	75.46	72.61	71.56	79.28

South Platte River Basin tends to increase. The trend is not always consistent, but it is clear that households with two or fewer children value improved water quality more than households with three or more children. The national trend is toward fewer children per household. This suggests that future changes in size of households may result in increased willingness to pay for water quality.

Size of household was not significant at the 5 percent level in a regression of variables associated with the value of improved water quality for recreation use. However, regression analysis showed a significant negative relationship between the size of household in Fort Collins and the option value of water quality, as measured by willingness to pay additional sales tax. As the number of children in households increased, option value decreased by $10.45 per year. This may be related to ability to pay. Smaller families have more income per person than larger families, at any given level of income. Thus, smaller families have more income available to pay additional sales tax for improved water quality.

RECREATION USE

Table 24 shows the reported number of water-based recreation activity days experienced annually in the South Platte River Basin by survey respondents and willingness to pay additional sales tax for improved water quality. Number of water-based recreation activity days was not significant in regression analysis of variables associated with recreation use and option value of improved water quality. The average values suggest that the relationship may be curvilinear. As recreation activity increases from zero to 21 days annually, the average value of water quality for recreation use also tends to increase. Over 21 days annually, water quality values fall off. This is particularly evident for Fort Collins residents. However, the tendency is not always consistent. Even in Fort Collins, the average option value of water quality increased continuously over the entire range of recreation use.

It seems that with the possible exception of values for recreation use in the Denver Metropolitan Area, those who are not currently engaging in water-based recreation activities in the River Basin may be less willing to pay for improved water quality to enhance recreation enjoyment of its use both now and in the future. Also, light users who report current water-based recreation activity as 1-7 days annually appear to have lower water quality values than either medium-heavy users of 8-21 days or heavy users of over 21 days annually.

Table 25 shows the reported number of water-based recreation activity days in the United States by survey respondents and willingness to pay additional sales tax for improved water quality. It shows the same general relationship as Table 24 .

The proportion of the population which participates in water-based recreation activities in the River Basin is difficult to estimate. Of the 101 households sampled in Denver, 79.2 percent reported participating

Table 24. Survey Respondent's Reported Annual Water-Based Recreation Activity Days in the South Platte River Basin and Willingness to Pay Additional Sales Tax for Improved (C-A) Water Quality, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976.

Water Quality Values	Annual Water-Based Recreation in the South Platte River Basin (Days)				
	0	1-7	8-21	Over 21	Total or Average
	Willingness to Pay Additional Sales Tax (Dollars per Year)				
Recreation Use Value					
Denver Metro Area	$49.22	$45.66	$51.71	$54.96	$50.18
Number Reporting ( )	(17)	(22)	(32)	(14)	(85)
Fort Collins	17.38	53.24	101.85	74.57	74.00
Number Reporting ( )	(8)	(18)	(29)	(34)	(89)
South Platte River Basin	38.43	47.76	65.60	60.39	56.68
Option Value					
Denver Metro Area	12.31	18.29	22.58	16.04	18.31
Number Reporting ( )	(17)	(24)	(32)	(15)	(88)
Fort Collins	2.09	28.43	43.39	36.58	34.05
Numbber Reporting ( )	(8)	(18)	(29)	(34)	(89)
South Platte River Basin	8.99	21.10	28.34	21.73	22.60
Total Value					
Denver Metro Area	61.53	63.95	74.29	71.00	68.49
Fort Collins	19.47	81.67	145.24	111.15	108.05
South Platte River Basin	50.05	48.86	93.94	82.12	79.28

Table 25. Survey Respondents' Reported Annual Water-Based Recreation Activity Days in the United States and Willingness to Pay Additional Sales Tax for Improved (C-A) Water Quality, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976.

Water Quality Values	Annual Water-Based Recreation in the United States (Days)				
	0	1-7	8-21	Over 21	Total or Average
	Willingness to Pay Additional Sales Tax (Dollars per Year)				
Recreation Use Value					
Denver Metro Area	$51.22	$46.01	$52.56	$53.10	$50.18
Number Reporting ( )	(9)	(30)	(30)	(27)	(85)
Fort Collins	7.60	50.44	94.89	81.41	74.00
Number Reporting ( )	(5)	(21)	(29)	(31)	(89)
South Platte River Basin	35.44	47.24	64.29	60.94	56.68
Option Value					
Denver Metro Area	12.81	16.66	21.86	19.44	18.31
Number Reporting ( )	(9)	(32)	(30)	(28)	(88)
Fort Collins	0.95	24.94	39.03	43.68	34.05
Number Reporting ( )	(5)	(21)	(29)	(41)	(89)
South Platte River Basin	8.42	18.95	26.62	26.15	22.60
Total Value					
Denver Metro Area	64.03	62.67	74.42	72.54	68.49
Fort Collins	8.55	75.38	133.92	125.09	108.05
South Platte River Basin	48.88	66.19	90.91	87.09	79.28

in water-based recreation activites in the South Platte River Basin, compared to 85.1 percent in Fort Collins. On this basis, the weighted average participation rate was estimated at 80.8 percent for residents of the River Basin in 1976. One reason for the rather high participation rate was the definition of what constituted water-based recreation activities. It was a broad one including the usual water sports--fishing, swimming, boating (power boat, sail boat, and canoe), and water skiing. Also included were non-contact recreation activities such as picnicking, sightseeing, pleasure drives, and hiking within sight of lakes and streams. Water quality was reported to enhance the enjoyment or aesthetic satisfaction of such recreation experiences.

This may appear to be a high estimate of participation in comparison to a 1972 census [Adams, Lewis and Drake, 1973] which shows that in the Western Region, 26.7 percent of the population fished, 5.9 percent water skiied, 2.2 percent canoed, 2.4 percent sailed, 17 percent used power boats, and 36.1 percent swam at a beach. However, 48.9 percent picnicked, 44 percent went sightseeing, 40.9 percent went driving for pleasure, 23.5 percent went on nature walks, and 14.2 percent bicycled. Many people engaged in more than one water-based recreation activity, and it is not possible to show the proportion of the total population who engaged in water-based sports and the proportion who did not. It is known that most boaters also fish and most swimmers also picnic. The Colorado Division of Parks and Outdoor Recreation estimates that residents of the state devoted an average of 32 days in all outdoor recreation activities in 1971. The present study found that all water-based recreation activities accounted for 20.3 days in the case of Denver residents and 26 days for Fort Collins residents. Thus water-based recreation accounted for about 62 percent in Denver and 81 percent in Fort Collins of average total outdoor recreation activities by Colorado residents. The weighted average number of water-based recreation days by River Basin residents was 21.6 days or a reasonable 67.5 percent of the average number of recreation activity days reported by Colorado residents in 1971.

The South Platte River Basin appears to be the most important location for water-based recreation activities by residents of both the Denver Metropolitan Area and outlying cities in the Basin such as Fort Collins. For the Denver residents sampled, the average number of water-based recreation days reported for 1976 was 12.8 or 63 percent in the South Platte River Basin. Fort Collins residents, the average number of water-based recreation days in the same year was 20.7 or 80 percent in the South Platte River Basin. The weighted average amount of water-based recreation in the River Basin was 15 days or an estimated 46.9 percent of the average number of recreation activity days reported by Colorado residents in 1971.

APPENDIX

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WATER QUALITY OPINION SURVEY

1. How long have you lived in the Denver (Fort Collins) area? (years)
2. Where did you live before you moved to this area? City _____
   Would you classify this as a:
   (1) Very large city or metro area (100,000+)
   (2) Medium-sized city (25,000 - 100,000)
   (3) Small City (5,000 - 25,000)
   (4) Rural area or town (non-farm)
   (5) Farm
   (6) Have always lived in this area
3. Why did you come here to live? (rank three most important)
   (1) A better job, higher income
   (2) Family
   (3) Cost of living
   (4) Climate
   (5) Recreation opportunities
   (6) Services
   (7) Health
   (8) Less pollution
   (9) Less congestion
   (10) School
   (11) Other
4. How many children do you have?
5. Which of the following best describes your family?
   (1) White
   (2) Oriental
   (3) American Indian
   (4) Black
   (5) Other
6. Is any of your family Spanish American or Mexican American?
7. Respondent's (1) Sex (2) Age (3) Years of formal education
   (4) Employment (5) Employer
   (6) Head of Household (0) No (1) Yes

   Coding:

Employment		Employer	
Professional	1	Small Business	1
Business owner/mgr.	2	Large Business	2
Skilled, foreman	3	Manufacturing	3
Salesman, buyer	4	Agriculture	4
Office worker	5	Petro-Chemicals	5
Unskilled	6	Mining	6
Housewife	7	Government	7
Retired	8	Unemployed	8
Student	9	Other	9
Other	0		

8. Which income category represents your total family income before taxes?
   (1) Under 6,000
   (2) 6,000 - 8,499
   (3) 8,500 - 10,999
   (4) 11,000 - 13,499
   (5) 13,500 - 15,999
   (6) 16,000 - 18,499
   (7) 18,500 - 20,999
   (8) 21,000 or more

9. Have you noticed any environmental problems in this area (e.g., air pollution, water pollution, land pollution (junk, dumps)? (0) No (1) Yes
10. Have any of these environmental problems affected your family or other people in this area (e.g., affected human health, damaged plants or livestock, reduced the enjoyment of life, or lowered property values)? (1) Nobody (2) Other people (3) Family (4) Other people and family
11. In general, how do you rate the waterways in the South Platte River Basin in terms of quality? (1) Poor (2) Fair (3) Good (4) Excellent
12. How would you classify lakes and streams in the South Platte River Basin as a source for your recreational enjoyment such as boating, swimming, fishing or viewing? (1) Very important (2) Important (3) Somewhat important (4) Not important
13. If you were asked to distribute an increase in federal revenue, what percentage of 100 would you use to improve each of the following? (1) National defense (2) Highways (3) Education (4) Health Services (5) Water quality (6) Air quality (7) Other

Coal development along with expanding mining operations may have significant effects on the quality of Colorado's water in the near future. As an aid in planning for the future I would like to find out how you feel about clean water for recreational activities. I have some questions which consider different ways of financing improved water quality. Let us consider three levels of water quality in a waterway such as the South Platte River Basin.

Suppose a sales tax was collected from the citizens of the South Platte River Basin for the purpose of financing water quality in this Basin. All of the additional tax would be used for water quality improvements to enhance recreational enjoyment. Every Basin resident would pay the tax. All bodies of water in the River Basin would be cleaned up by 1983. Assume that this is the only way to finance water quality improvement.

14. Would you be willing to add _____ cents on the dollar to present sales taxes every year, if that resulted in an improvement from situation C to situation B?
15. Would you be willing to add _____ cents on the dollars to present sales taxes every year, if that resulted in an improvement from situation C to situation A?
16. (If 14 and 15 "zero" choose <u>one</u>). Did you answer "zero" because:
    (1) You do not suffer any ill effects from water pollution and therefore see no reason to reduce it?
    (2) You believe taxes are already too high?
    (3) You believe it is unfair to expect people adversely affected to pay the costs of reducing water pollution?
    (4) Other

Now let's consider a different way of financing water quality improvement. Suppose an extra water bill charge was collected from citizens of the South Platte River Basin for the purpose of financing water quality in this Basin. All of the additional charge would be used for water quality improvements

to enhance recreational enjoyment. Every Basin resident would pay the charge. All bodies of water in the River Basin would be cleaned up by 1983. Now assume that this is the only way to finance water quality improvement.

17. Do you think it would be reasonable to add _____ to your water bill every month, if that resulted in an improvement from situation C to situation B?
18. Do you think it would be reasonable to add _____ to your water bill every month, if that resulted in an improvement from situation C to situation A?
19. (If 17 and 18 "zero" choose one.) Did you answer "zero" because:
    (1) You do not suffer any ill effects from water pollution and therefore see no reason to reduce it?
    (2) You believe your water bill is already too high?
    (3) You believe it is unfair to expect people adversely affected to pay the costs of reducing water pollution?
    (4) Other
20. If situation A was not achieved until the year 2000, how would this delay affect your payment of the (1) Sales tax from your original estimate of _____ (2) Water bill charge from your original estimate of _____.
21. (If all Colorado residents and tourists would pay the sales tax:) (If all Colorado water users would pay the water bill charge:) how would improving the quality of water to level A by 1983 throughout Colorado for recreational enjoyment affect your payment of the: (1) Sales tax from your original estimate of _____? (2) Water bill charge from your original estimate of _____?
22. How many days per year do you spend at water-based recreation such as fishing, boating, swimming, picnicking near streams, etc: (1) In the South Platte River Basin? (2) Anywhere in the United States?
23. How well do you like doing these activities?
    (1) Dislike very much
    (2) Dislike
    (3) Indifferent
    (4) Like
    (5) Like very much
24. What would you estimate are the chances in 100 that you will travel to lakes and streams in the South Platte River Basin in the next year, for water-based recreation if they are preserved at level A? (2) Do you anticipate any significant change in your chances for future years? (3) (If "yes") What change?
25. Given your chances of future use would you be willing to add _____ cents on the dollar to present sales taxes every year for water recreation opportunities at lakes and streams in the South Platte River Basin if they are preserved at level A? Would it be reasonable to add _____ to your water bill every month for these opportunities?

In the near future, one of two alternatives is likely to occur in the South Platte River Basin. The first alternative is that a large expansion in mining development will soon take place, creating jobs and income for the region. As a consequence, however, many lakes and streams would become severely polluted. It is highly unlikely, as is shown in situation C, that

these waterways could ever be returned to their natural condition. They could not be used for recreation. Growing demand could cause all other waterways in the area to be crowded with other recreationists.

The second possible alternative is to postpone any decision to expand mining activities which would irreversibly pollute these waterways. During this time, they would be preserved at level A for your recreational use. Furthermore, information would become available enabling you to preserve the waterways at level A for your recreational use or to permit mining development. Of course, if the first alternative takes place, you could not make this future choice since the waterways would be irreversibly polluted.

26. Given your chances of future recreational use, would you be willing to add _____ cents on the dollar to present sales taxes every year to postpone mining development? This postponement would permit information to become available enabling you to make a decision with near certainty in the future as to which option (recreational use or mining development) would be most beneficial to you? Would it be reasonable to add _____ to your water bill every month for this postponement?
27. If it were certain you would not use the South Platte River Basin for water-based recreation, would you be willing to add _____ cents on the dollar to present sales taxes every year, just to know clean water exists at level A as a natural habitat for plants, fish, wildlife, etc? Would it be reasonable to add _____ to your water bill every month for this knowledge?
28. If it were certain you would not use the South Platte River Basin for water-based recreation, would you be willing to add _____ cents on the dollar to present sales taxes every year to ensure that future generations will be able to enjoy clean water at level A? Would it be reasonable to add _____ to your water bill every month for this knowledge.
29. Who do you think should pay the costs of water qulaity preservation?
    (1) The people benefiting by it, i.e., the local residents and other recreationists.
    (2) The final consumer of the things produced by polluting recreationists.
    (3) The polluting firms.
    (4) Some combination of the above (Which bears primary responsibility?)
    (5) The community as a whole.

ENVIRONMENTAL AWARENESS

Table 26 shows that residents of both cities tend to be sensitive to their environmental surroundings. In both Denver and Fort Collins, nearly 84 percent of the residents interviewed report that they are aware of environmental problems in the area such as air pollution, water pollution and solid waste pollution (i.e., visible junk). Nearly half of the residents interviewed report that these environmental problems have affected their family or other persons in the area, as for example, human health, damaged plants or animals, reduced enjoyment of life or lowered property values. There is more personal contact with environmental problems in the large city. A reported 36.6 percent of households in Fort Collins had personal contact with environmental problems compared to 50.0 percent in Denver.

Over half of the residents of the two cities rated the quality of waterways in the South Platte River Basin as either poor or fair. Few respondents (only about 4 percent) rated the quality of water in the River Basin as excellent. The largest proportion of respondents (47.2 percent) rated the quality of water in the River Basin as fair, and about 15.4 percent rated its water quality as poor. One-third (33.7 percent) of the respondents rated the quality of water in the River Basin as good. This is particularly true for residents of Fort Collins where water quality deterioration is not as evident as in the Denver Metropolitan Area.

Table 26 shows that residents of both cities consider the South Platte River Basin an important recreation resource. Thirty percent of households in Fort Collins report that the River Basin is very important as a recreation resource compared to 20.0 percent in Denver. About 30 percent of households in Denver report that the River Basin is somewhat important as a recreation resource compared to 15 percent in Fort Collins. Residents of Fort Collins tended to rate the importance of the River Basin as a recreation resource more highly than residents of Denver. The Poudre River Canyon, a major tributary to the South Platte River, emerges from the mountains just above Fort Collins, and Horsetooth Reservoir is located in the foothills west of the city. Both are heavily used for day outings by residents of Fort Collins. The incidence of use of the South Platte River as it passes through Denver is much less by comparison.

The table also shows that residents of both cities would be willing to distribute a substantial portion of increased federal revenues appropriated by Congress to water and air quality improvement. In both Denver and Fort Collins, the residents interviewed report that they would distribute about 40 percent of an increase in federal revenues for improved water and air quality. They would allocate 22 percent of increased federal revenues to improved water quality, and nearly 20 percent to improved air quality. Allocations to other public services are shown in the table. Improved health services would receive nearly 18 percent, as would education. Highways would receive less than 7 percent, national defense 10 percent and other public services about 5 percent.

Table 26. Environmental Awareness of Residents, Denver, Fort Collins, and South Platte River Basin, Colorado, 1976.

Environmental Concern	Denver Metropolitan Area	Fort Collins	South Platte River Basin
	Percent of Sample		
Awareness of Environmental Problems in the Area	84.2	83.2	83.9
Knowledge of Environmental Damages			
Personal Knowledge	50.0	36.6	46.3
Respondent's Household	11.2	5.0	9.5
Other Households	4.1	5.9	4.6
Both Respondent's Household and Other Households	34.7	25.7	32.3
No Personal Knowledge	50.0	63.4	53.7
Quality Rating of South Platte River Basin			
Poor	18.2	7.9	15.4
Fair	48.5	43.6	47.2
Good	30.3	42.6	33.7
Excellent	3.0	5.9	3.8
Importance of South Platte River Basin for Recreation Use			
Very Important	20.0	29.7	22.7
Important	35.0	40.6	36.5
Somewhat Important	29.0	14.9	25.2
Not Important	16.0	14.9	15.7
Preferred Distribution of Increased Federal Revenues			
Water Quality	21.3	23.4	21.9
Air Quality	19.5	19.6	19.5
Health Services	17.4	17.7	17.5
Education	17.7	18.5	17.9
Highways	6.4	7.9	6.8
National Defense	10.8	8.9	10.0
Other	6.1	3.7	5.4

STATISTICAL ANALYSIS

SPECIFICATION OF THE REGRESSION MODELS

The hypothesis is that the dependent variable willingness to pay, Y, is a function of the specific socioeconomic characteristics of the survey participants. Independent socioeconomic variables X_1 through X_{30} were used in estimating the regression equations although not all of the variables were found to be statistically significant. Dummy variables were used for qualitative socioeconomic categories. These include: sex, size of former residence, occupation, and employer.

Various other algebraic forms including linear, hyperbolic, quadratic, and log functions were estimated. The linear model was chosen for the subsequent evaluations since it provided the best fit. The functions with insignificant constants were forced through the origin with no improvement in the percentage of explained variance or in the numbers of significant coefficients. Significant hyperbolic terms were checked for consistency through use of log transformations. Since consistent results were obtained the hyperbolic terms were retained in the final estimated equations.

Four models were considered. These models may be formulated as:

$$Y = a + Z_h + Z_i + Z_j + Z_k + B_1X_1 + B_2X_2 + . \ . \ . \ , + B_nX_n + E$$

where Y may be defined as:

MODEL I — Resident household willingness to pay an increased sales tax for improved water quality to enhance recreation.

MODEL II — Resident household willingness to pay an increased water bill for improved water quality to enhance recreation.

MODEL III — Resident household willingness to pay an increased sales tax for option value of improved water quality.

MODEL IV — Resident household willingness to pay an increased water bill for option value of improved water quality.

The regression parameters are:

a	joint reference category intercept value
Z_h	net effect of sex, h = 1, 2
Z_i	net effect of previous residence, i = 1, . . , 4
Z_j	net effect of occupation, j = 1, . . , 4
Z_k	net effect of employment, k = 1, . . , 4
B_n	regression coefficient for the continuous variables
E	Stochastic disturbance variables

All four models are estimated for both the Denver Metropolitan Area and Fort Collins.

Variables Used in Analysis of Relationship Between Willingness to Pay and Socioeconomic Characteristics:

Y_1	Annual amount willing to increase sales tax for improved water quality
Y_2	Annual amount willing to increase water bill for improved water quality
Y_3	Annual amount willing to increase sales tax for option value
Y_4	Annual amount willing to increase water bill for option value
X_1	Gross annual family income
X_2	Annual South Platte River Basin water-based recreation days
X_3	Annual water-based recreation days, total
X_4	Age
X_5	Years of formal education
X_6	Female, 0 (dummy reference category)
X_7	1 if male, 0 otherwise
X_8	Population of previous residence--under 5,000, 0 (dummy reference category)
X_9	1 if population of previous residence 5,000-25,000, 0 otherwise
X_{10}	1 if population of previous residence 25,000-100,000, 0 otherwise
X_{11}	1 if population of previous residence 100,000+, 0 otherwise
X_{12}	Occupation--all other including: foreman, salesman/buyer, office worker, unskilled and student 0 (dummy reference category)
X_{13}	1 if occupation professional, business owner, or manager, 0 otherwise

X_{14} 1 if occupation housewife, 0 otherwise
X_{15} 1 if occupation retired, 0 otherwise
X_{16} Employer--all other including unemployed 0 (dummy referency category)
X_{17} 1 if employed in small business or agriculture, 0 otherwise
X_{18} 1 if employed in large business or manufacturing, 0 otherwise
X_{19} 1 if employed in government, 0 otherwise
X_{20} Number of children in family
X_{21} Years lived in present city
X_{22} 1/Gross annual family income
X_{23} 1/Age
X_{24} 1/Years lived in present city
X_{25} 1/Years of formal education
X_{26} Family income x Age
X_{27} Family income squared
X_{28} Age Squared
X_{29} Years of formal education squared
X_{30} Number of children in family squared

STATISTICAL RELIABILITY OF THE SOCIOECONOMIC REGRESSIONS

The least squares regression estimation procedure is founded on the assumption that the disturbance terms are normally distributed with a zero mean and constant variance. There are a number of statistical problems associated with regression analysis of economic data which may violate this assumption resulting in biased and/or inconsistent estimators. Among these are multicollinearity, heteroscedasticity, mis-specification of the model, non-random disturbance terms, and non-normally distributed sample values. These problem areas will be briefly discussed in relation to the preceding analysis.

Multicollinearity arises when at least one of the independent variables is a linear combination of the others. This results in a situation of too few independent normal equations so that estimators cannot be derived for all of the coefficients. A classic symptom of multicollinearity occurs when a large coefficient of determination is produced while estimators of the coefficients are found to be insignificant. It might arise when high correlation exists between such variables as education or age and income. This was not the situation in the preceding analysis. Very low correlation was observed between the variables comprising the socioeconomic data generated from the survey. Only a very

few pairs of variables had correlation coefficients exceedings .50. The symptom of insignificant coefficient estimators in conjunction with large R^2 values was not observed. Thus there was no available evidence to suggest that multicollinearity resulted in any difficulty in estimating the regression coefficients.

The condition of nonconstant variance among the error terms in called heteroscedasticity. Since it is assumed in regression analysis that the variance of the error term is constant, this assumption is violated when heteroscedasiticity occurs. The least squares estimation procedure produces an estimate of error term variance used in calculating the standard errors of the coefficients. These standard errors will become an average of the differing variances of the error terms. Since the estimator does not produce the statistic with the smallest variance tests of hypothesis and confidence interval estimates derived by using the t-statistic will be suspect. The variance of the disturbance terms may be expected to increase as household income increases. Wealthy people generally have greater variability in their consumption patterns than do the poor. This situation was not apparent from a plot of the least squares residuals against willingness to pay estimates. Variance among the error terms appeared to be constant as willingness to pay estimates increased. There was no evidence to suggest the variance among the error terms was heteroscedastic.

Omission of an important independent variable may lead to a violation of the assumption of an expected zero mean for the error term. The low coefficients of determination of the various socioeconomic regressions might lead one to the conclusion that a significant variable not among those listed may have been omitted. One case in point is that there were no independent variables available which adequately served as an indicator of tastes and preferences of the participating residents regarding their enjoyment of the natural environment in general and water-based recreation activity in particular. Respondents were asked how well they liked outdoor water-based recreation on a 4 point scale from dislike very much to like very much. This scale did not provide sufficient detail to detect differences in the tastes of the respondents. Almost all respondents indicated that they either "liked" or "liked water-based recreation very much." Likewise, the number of water-based recreation activity days failed to indicate adequately the tastes of the residents for outdoor recreation. This was most likely the result of respondents who spent little time in these activities because of work or time restrictions but enjoyed water-based recreation activity very much. Other respondents reported spending a large number of days engaged in water-based recreation activity, not so much because they personally enjoyed them as they wished to please other members of their families. Greater emphasis on the development of a refined question designed to reflect tastes and appreciation of the outdoor environment may mitigate this problem. Randall [1977] reported a similar problem in a study of the benefits to abatement of air particulates in the Four Corners area of the Southwest.

The relatively low coefficients of determination may also be the result of omitting other significant variables associated with environmental concern. Our findings are less pessimistic than Eastman, Hoffer and Randall [1974] who concluded that concern for the environment may tend to be randomly distributed among residents of the Four Corners area. The authors suggest that:

> "A tentative explanation of this randomness may be that attention has focused on environment only recently and attitudes have not yet fully crystalized. With time, a more patterned relationship may emerge. Or it may be that aesthetic concerns are inherently less patterned than many other phenomena."

The fit of the regression equations in this study was somewhat higher then that of the equations estimated by Eastman, Hoffer and Randall [1974]. A pattern, although somewhat weak, signified by the repeated occurrence of variables affecting willingness to pay was also more pronounced in this study. It may be that characteristics affecting environmental concern are crystalizing throughout the population but are still not fully identified. Interestingly, although it might be expected that a more homogenous population would be found in a small university town, benefit estimates were more highly associated with socioeconomic profile characteristics of Denver residents. Perhaps attitudes toward the natural environment have crystalized more rapidly in the more densely populated Denver Metropolitan Area than in Fort Collins.

The willingness to pay bids generated from the survey were estimates of the amount of household income respondents would allocate to water quality improvement. They may have been subject to errors in measurement on the part of the respondents. This may have resulted in low R^2 values, as log linear, hyperbolic and quadratic transformations did not improve the fit of the data.

There were no apparent trends in the overall plot of the residuals and plots of the residuals against the dependent and relevant independent variables. There was however, an outlier problem associated with high bid estimates which could not be mitigated by use of any of the available independent variables. This problem may be related to the lack of a sufficient indicator of tastes or unpredictable behavior as discussed above.

Although plots of the estimated use and non-use values appear to be normally distributed, there is a cluster of values at the zero point. Respondents were not permitted to associate negative values of recreational opportunities derived from water quality improvement. Hence the normal distribution curve of values becomes truncated instead of asymptotic. The 95 percent confidence intervals for the estimated coefficients of the independent variables are generally large. This problem reduces the predictive ability of the equations.

The statistical relationship between willingness of residents to pay for improved water quality and socioeconomic characteristics is estimated through use of variance estimators, based on sample responses to hypothetical situations. It is impossible to indicate what effect the introduction of a real as opposed to a hypothetical payment situation would have on the willingness to pay variance estimators and hence the estimated statistical relationships.

GROUPED T-TESTS OF SIGNIFICANT DIFFERENCES BETWEEN AVERAGE BENEFITS IN DENVER AND FORT COLLINS

There is a large difference in the reported mean values of benefits for Denver and Fort Collins residents. Given the sizeable dispersion of individual benefit estimates, the apparent difference between means must be tested to see if it exceeds that which might occur randomly. Table 27 shows the results of the group t-test, comparing corresponding Denver and Fort Collins benefit values. The t-test provides an estimate of the significance of the difference in the reported mean values for the two cities. None of the t value statistics are significant at the 5 percent level and only two at the 10 percent level. On the basis of these tests, we conclude that there is no strong evidence of any difference between the reported mean values for Denver and Fort Collins residents. We do not find evidence in this study to support the hypothesis that residents of smaller cities would be willing to pay more for water-based recreation than residents of large cities.

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Table 27 . Grouped T-test of Significant Difference Between Average Benefits from Improved Water Quality in Denver and Fort Collins, Colorado, 1976.

Mean Water Quality Values	T Value[a/]	Two Tail Probability That Means Are Equal
Recreation Use Value		
Improvement from Polluted Water to an Intermediate Level of Water Quality (C-B)		
Sales Tax Levy	1.32	.811
Water Bill Surcharge	1.17	.756
Improvement from Polluted Water to Highest Level of Water Quality (C-A)		
Sales Tax Levy	1.65	.899
Water Bill Surcharge	1.04	.697
Improved Water Quality Delayed to the Year 2000		
Sales Tax Levy	.72	.524
Water Bill Surcharge	.92	.638
Improved Water Quality Throughout Colorado		
Sales Tax Levy	1.89	.939
Water Bill Surcharge	1.13	.740
Preservation of Water Quality at Level A		
Sales Tax Levy	1.49	.862
Water Bill Surcharge	.72	.528
Option Value		
Sales Tax Levy	1.51	.868
Water Bill Surcharge	1.01	.684
Existence of Natural Ecosystem		
Sales Tax Levy	1.69	.907
Water Bill Surcharge	.99	.676
Bequest to Future Generations		
Sales Tax Levy	1.55	.876
Water Bill Surcharge		.617

[a/] Tests the significance of difference between the compared mean values at the 5 percent level.

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